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Distributive Politics and the Costs of Centralization

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This paper studies the choice between centralization and decentralization of fiscal policy in a political economy setting. With centralization, regional delegates vote over agendas comprising sets of region-specific projects. The outcome is inefficient because the choice of projects is insufficiently sensitive to within-region benefits. The number of projects funded may be non-monotonic in the strength of project externalities. The efficiency gains from decentralization, and the performance of "constitutional rules" (such as majority voting) which may be used to choose between decentralization and centralization, are then discussed in this framework. Weaker externalities and more heterogeneity between regions need not increase the efficiency gain from decentralization.

1. INTRODUCTION

There is, in many countries, continuing discussion over the desirable degree of fiscal decentralization. For example, in the United States, there has been debate about the appropriate sharing of tax and expenditure powers between Federal and State governments since the drafting of the U.S. Constitution (Inman and Rubinfeld (1997*a*)). In Canada, similar debates have been made more acute as a result of Quebec separatism (Jackson *et al*. (1986)). In the European Union, the principle of subsidiarity, introduced in the Maastricht Treaty, "remains vague and capable of conflicting interpretations" (Begg *et al*. (1993)).

The earlier literature on decentralization, and in particular Oates' seminal work (Oates (1972)) gave the following account of costs and benefits of decentralization. Sub-central governments may find it hard to coordinate to internalize inter-jurisdictional externalities, or to exploit economies of scale, in the provision of regional public goods. On the other hand, the cost of centralization is less "responsiveness" to the preferences of regions in the choice of type or quantity of public good by government. Specifically, in Oates' work, the cost of centralization was modelled as *policy uniformity i.e.* it was assumed that if a regional public good were provided centrally, it would be provided at the same quantity per capita in every region.[1] This leads to the conclusion[2] (Oates' "decentralization theorem"), that there is an efficient level of decentralization of the provision of a public good, where the additional benefit from less policy uniformity is balanced by the loss due to less efficient internalization of externalities.

While providing important insights, Oates' account suffers from the problem[3] that the hypothesis of "policy uniformity" is not derived from any explicit model of government behaviour. Indeed, explicit models of collective choice tend to give a different account of

1. Other authors have extended this policy uniformity outcome to other instruments such as tax rates (*e.g.* Bolton and Roland (1997)).

2. See p. 35 of Oates (1972).

3. It is also not consistent with the evidence in that, typically, spending by central governments is not uniform across regions in per capita terms. For example, the formulae used to allocate U.S. federal block grants depends not only on population, but also on income per capita, tax raising effort, and several other factors (Boadway and Wildasin (1984)), and this is also true of other countries with formula-based intergovernmental grants (Costello (1993)).

what might happen with centralized provision of local public goods. For example, the large "distributive politics" literature on the centralized provision of local public goods (*e.g.* Weingast (1979), Shepsle and Weingast (1979), Ferejohn, Fiorina and McKelvey (1987)) tends to conclude that local public goods will only be provided to "minimum winning coalitions", rather than uniformly.

However, the distributive politics literature cannot be applied directly to refine Oates' argument, as it does not model the benefits of centralization that arise from the internalization of externalities. The first objective of this paper is to integrate these two literatures, by formulating a model where (i) with centralization, legislative behaviour is rigorously modelled, with the primitives being legislative rules, rather than outcomes; (ii) externalities between regions generated by region-specific projects give some rationale for centralization. A second objective is to apply this model to study the nature of the inefficiency of centralized decision-making, and derive conditions under which decentralization may be more efficient.

Absent externalities, our model is in many respects standard in the distributive politics literature. Specifically, every region has a discrete project which generates both intra-regional benefits and external benefits (or costs). All voters within a region are identical, but regions may vary both with respect to the cost and the benefit of their project, and in the externalities they impose on other regions. With decentralization, regions both choose and finance their own projects. With centralization, regional delegates form a legislature, which then decides on which projects are to be financed out of the proceeds of a national income tax.[4]

In this legislature, the policy space is multi-dimensional and so majority voting is generally not transitive. So, we proceed by imposing some minimal rules on the legislature. Specifically, delegates first propose alternatives (bundles of projects) for consideration, and then, all proposed alternatives are then voted on according to an amendment agenda. Following Ferejohn, Fiorina and McKelvey (1987), we assume that the agenda must have the feature (very widely observed in practice) that a distinguished status quo alternative exists, which we take to be the alternative of no project in any region. With a distinguished status quo, "*any agenda must have the feature that the last vote fits the bill as amended against the status quo*" (Ferejohn, Fiorina and McKelvey (1987)). These legislative rules describe a multi-stage game played by the delegates. The equilibrium outcome is a set of projects chosen for funding.

In general, the equilibrium set of projects will depend on the order of items on the agenda. This is undesirable as then the predicted outcome with centralization will depend on the fine detail of the legislative process. Our first result[5] states that with a distinguished status quo, the order of the alternatives on the agenda is in fact, *irrelevant* if there exists a Condorcet winner (CW) in the subset of policy alternatives that are preferred to the status quo; in this case, the only possible equilibrium outcome is this "restricted" CW. We then establish some assumptions on the structure of the externalities under which there exists a unique restricted CW.

The nature of this restricted CW is the following. Every region i imposes a *net spillover* on every other region j, which comprises the project spillover, minus $j's$ tax share of the cost of funding $i's$ project. By assumption, all regions agree on the sign of net spillovers. If all net spillovers are negative, the restricted CW funds projects in the simple majority of regions whose projects impose the smallest net spillovers (in absolute value) on the others. Otherwise, it funds the set of regional projects whose net spillovers are all positive.

This characterization of the outcome with centralization has two important implications. First, the set of projects funded is *insensitive to within-region benefits*. So, we can justify

4. We extend the distributive politics literature by not requiring this tax to be levied at a uniform rate across regions.

5. This result is a generalization of Theorem 1 of Ferejohn, Fiorina and McKelvey (1987).

rigorously the widely-made assertion that centralized government is less sensitive to the "tastes" of citizens than decentralized government.[6] Second, the number of projects funded is not everywhere monotonic in the number of projects with positive net spillovers: when this number rises from zero to one, the number of projects funded *falls*.

Building on this characterization of the centralized outcome, the second contribution of the paper is a thorough investigation of the efficiency gains from decentralization, both in the sense of aggregate surplus, and in the Pareto sense. Oates (1972) showed that if policy uniformity is assumed, the surplus gains from decentralization are higher when (i) regions are heterogenous and/or (ii) inter-regional spillovers are small. In our model, where policy uniformity is not exogenously assumed, it is not obvious that these results should extend. We find that while conditions can be found under which they do, there are some important qualifications.

First, the gain in surplus from centralization is not necessarily everywhere increasing in the size of the externality; this is related to the non-monotonicity of project funding as net spillovers increase. Second, the conditions under which increased heterogeneity increases the efficiency of decentralization are quite stringent.[7] Finally, we find that centralization only Pareto-dominates decentralization (*i.e.* all citizens prefer the first arrangement) when all net spillovers are positive and there is minimal heterogeneity between regions, but by contrast, even if there are no spillovers, *some* region will strictly gain from centralization, so decentralization can *never* be Pareto-preferred in this case.[8] This is because the cost-pooling will always benefit some high-cost region.

A third contribution of the paper is to study the choice of constitution by majority and unanimity rule. If project costs are sufficiently heterogenous, a majority will always prefer decentralization when there are no spillovers. Conversely, when all net spillovers are positive, and there is minimal heterogeneity in costs, a majority prefers centralization.

The rest of the paper is laid out as follows. Section 2 reviews some related literature while Section 3 exposits the model. Section 4 analyses political equilibrium under centralization. Section 5 derives conditions under which centralization or decentralization is the more efficient. Section 6 considers issues of constitutional design. Section 7 considers the robustness of the results to various extensions of the model, and also discusses applications. Section 8 concludes.

2. RELATED LITERATURE

There is already a body of work[9] which addresses (explicitly or implicitly) the choice between centralization and decentralization, while taking a political economy approach to the modelling of government behaviour (Alesina and Spolare (1997), Bolton and Roland (1996, 1997), Cremer and Palfrey (1996), Ellingsen (1998), Besley and Coate (1997)). However, Alesina and Spolare

6. This equilibrium benefit-insensitivity is closely related to Olson's (1986) concept of "internality": As he says, "the gains from providing a local public good of exogenous domain can greatly exceed the costs of providing it, but with a unitary national jurisdiction, the number of losers from the national taxes that would finance the public goods will be far larger than the number of gainers. Thus the provision of the local public good will fail to command a majority of the larger jurisdiction".

7. This is consistent with the results of Wallis and Oates (1988) and others, who do not find any strong evidence that linguistic and ethnic heterogeneity lead to greater fiscal decentralization.

8. In fact, we prove a stronger result: decentralization can never be Pareto-preferred if every project that is funded under decentralization is also funded under centralization.

9. One should also note the work of Edwards and Keen (1996) and Seabright (1996), where government is modelled as a Leviathan. The problem with such models of government behaviour, however, is that they are not based explicitly on the primitives of voters, legislative rules and the principal-agent relationship between voters and bureaucrats. There are also a number of papers which model government as welfare-maximizing (see *e.g.* Caillaud, Gilbert and Picard (1996), Gilbert and Picard (1996), Klibanoff and Poitevin (1996), Seabright (1996)). The challenge for these papers is to explain why decentralization might ever be welfare-superior to centralization; if central government can precommit, it can always replicate the decentralized outcome.

(1997), Bolton and Roland (1997) and Cremer and Palfrey (1996) follow Oates in assuming that centralized policy is uniform.[10]

Bolton and Roland (1996) and Ellingsen (1998) depart from Oates' assumption, but in settings where there are two regions (or groups) of unequal size, so the larger group dictates policy. In Ellingsen, the policy decision is the level of expenditure on a pure (national) public good, so if it is provided at a given level in one region, it is also provided at that level in the other region (*de facto* uniformity). Bolton and Roland (1996) analyse a model where two groups of agents value different public goods, and one group is larger than the other, so only the public good of the majority is provided—again, *de facto* uniformity.

Finally, there is the independent contribution of Besley and Coate (2000), which is much closer to this paper. In fact, the two papers are very complementary. First, unlike this paper,[11] Besley and Coate (2000) focus on the role of *strategic voting for delegates* to the legislature. Specifically, in their model, populations in regions are heterogenous, and any citizen may stand as a candidate for election. So, voting in a delegate with a strong preference for public spending is a precommitment mechanism that allows that region to capture more of the available tax revenue for its own projects. This is a source of inefficiency with centralized provision.

Second, in order to focus on strategic voting, Besley and Coate assume just two regions, and very special rules of operation of the legislature.[12] By contrast, in this paper, we study a many-region model where the rules of operation of the legislature are the minimal ones needed to ensure a determinate outcome, given the underlying intransitivity of majority voting over the policy space.

This difference in approach generates differences in conclusions. For example, Besley and Coate show that if regions are identical, then decentralization produces a higher level of economic surplus when spillovers are small enough (Proposition 2 in their paper), and therefore Pareto-dominates centralization. In contrast, Proposition 4 below shows that in our setting, decentralization can never Pareto-dominate centralization, even when spillovers are zero.

3. THE MODEL

3.1. *Preliminaries*

There are an odd number $i = 1, \dots, n$ of regions or districts each populated by a number of identical individuals with a population size normalized to unity. In each district there is a discrete project $x_i \in \{0, 1\}$ which if undertaken ($x_i = 1$), costs c_i units of a divisible private good. The project in region i generates benefit b_i for residents of i, and also external benefit e_{ji} for residents of region $j \neq i$. By definition, $e_{ii} = 0$. The externality e_{ji} may be positive or negative. We also assume $b_i \neq c_i$ to avoid dealing with non-generic cases that complicate the statement and proof of results.

10. In Bolton and Roland (1997), the centralized case is what they call "unification", in which case policy (an income tax) is uniform across two regions. In Cremer and Palfrey (1996), an abstract policy variable is set at the same level in every region with centralization. Alesina and Spolare (1997) consider a model where the number and geographical size of units of government is determined endogenously, but within the borders of each unit, policy (the level of government services) is uniform.

11. We abstract from this important issue in our model, by assuming that the population within any region is homogenous.

12. They consider two scenarios, the non-cooperative and the cooperative. In the first, each of the two delegates to the legislature (there are only two regions in their model) is chosen as agenda-setter with probability 0.5, and then chooses public good levels in both regions to maximize his own utility only. In the cooperative case, the legislature is assumed to maximize the sum of utilities of the two delegates.

Let $F = \{i \in N \mid x_i = 1\}$ be the set of regions that have funded projects. Then all residents of region i have identical preferences over F and the private good of the form

$$u_i = \begin{cases} b_i + y_i + \sum_{j \in F} e_{ij} & \text{if } i \in F, \\ y_i + \sum_{j \in F} e_{ij} & \text{if } i \notin F, \end{cases} \tag{3.1}$$

where y_i is the level of consumption of the private good. Note at this stage, our modelling of externalities is completely general, except that utilities are assumed additively separable in the different external effects.

A resident of region i has initial endowment of ω_i units of the private good. Every resident of i pays an income tax levied at rate t_i on this endowment, either to regional or central government. So, the budget constraint for any resident of region i is $y_i = (1 - t_i)\omega_i$. So substituting this constraint into (3.1), and suppressing the constant of ω_i, we get

$$u_i = \begin{cases} b_i - t_i\omega_i + \sum_{j \in F} e_{ij} & \text{if } i \in F, \\ -t_i\omega_i + \sum_{j \in F} e_{ij} & \text{if } i \notin F, \end{cases} \tag{3.2}$$

For future reference, note that however projects are funded, a project is efficient[13] if the benefit, plus any externalities, exceeds the cost *i.e.*

$$b_i + \sum_{j \in N} e_{ji} \geq c_i. \tag{3.3}$$

3.2. *Decentralization*

With decentralization,[14] the project is funded by a regional income tax, so the regional budget constraint is $t_i\omega_i = c_i$ if the project is undertaken. So, from (3.2), the net benefit of the project to any resident is $b_i - c_i$. We assume a decision about the project is made by majority voting over the alternatives $x_i \in \{0, 1\}$. So, as all agents in a region are identical, the outcome under decentralization is simply that the project in i is funded if $b_i \geq c_i$. So, $D = \{i \mid b_i \geq c_i\}$ is the set of projects funded under decentralization, and for future reference, note that the payoff to a resident of i can be written

$$u_i^d = \begin{cases} b_i - c_i + \sum_{j \in D} e_{ij} & \text{if } b_i \geq c_i, \\ \sum_{j \in D} e_{ij} & \text{if } b_i < c_i. \end{cases} \tag{3.4}$$

Comparing the decentralized project funding rule with (3.3), it is clear that in the presence of externalities, the outcome with decentralization is generally not efficient.

3.3. *Centralization*

We assume that in this case, *both* the decisions about which projects to fund, and the setting of a tax to fund them, are made by a legislature that comprised of delegates from all regions.[15] The distributive politics literature assumes that it is a constitutional constraint that the income tax rate

13. In the sense of maximizing the aggregate surplus in the economy, which is well-defined, as preferences are linear in income.

14. Obviously, in this simple framework, there is no difference (for a particular region) between decentralization and secession. In a richer model, such as that of Bolton and Roland (1997), one can distinguish between the two, for example in the degree to which factors of production are mobile.

15. This is the way that centralization is usually defined, but there are of course, two alternative kinds of *partial* centralization; the first is *centralized expenditure*, where projects are decided upon by central government, but are funded by regions as in Section 3.2 above, and the second *centralized funding*, where projects are decided upon regionally, but funded through a national tax (these alternatives are discussed in Lockwood (1998)).

is uniform across regions. We will generalize this by allowing the legislature to set different taxes across regions. So, the national government budget constraint is

$$\sum\nolimits_{i\in N} t_i\omega_i = \sum\nolimits_{j\in C} c_j, \tag{3.5}$$

where C is the set of projects funded with centralization. Throughout the analysis, we will assume that the *relative* tax rates are t_i/t_j exogenously fixed, although obviously the actual taxes will vary with project provision. It follows from (3.5) that given a set of projects C, any resident of i will pay tax of

$$t_i\omega_i = \lambda_i \sum\nolimits_{j\in C} c_j, \quad \lambda_i = \frac{t_i\omega_i}{\sum_{i\in N} t_i\omega_i}, \tag{3.6}$$

so that λ_i is the (exogenous) *cost share* of residents of i. In the special case of equal incomes ($\omega_i = \omega$) and a uniform tax ($t_i = t$, $i \in N$), cost shares are equal *i.e.* $\lambda_i = 1/n$. We will assume only that $\lambda_i > 0$, $i \in N$ in what follows.

We make the reasonable assumption that the delegate from region i must be drawn[16] from the (homogenous) population in that region, consistently with the citizen-candidate model (Besley and Coate (1997)). Combining this with (3.1), (3.2), and (3.6), we see that the payoff to both any resident of region i and its delegate from any set of funded projects C is

$$u_i^c(C) = \begin{cases} b_i - \lambda_i \sum_{j\in C} c_j + \sum_{j\in C} e_{ij} & \text{if } i \in C, \\ -\lambda_i \sum_{j\in C} c_j + \sum_{j\in C} e_{ij} & \text{if } i \notin C. \end{cases} \tag{3.7}$$

This indicates that with centralization, there are *two* kinds of spillovers at work; the first are the project spillovers, captured by the terms e_{ij}, and the second are the *cost-sharing* spillovers captured by the terms $\lambda_i c_j$. Thus region i benefits from a project in region j by the *net spillover*

$$\sigma_{ij} = e_{ij} - \lambda_i c_j, \; i \neq j.$$

By definition, $\sigma_{ii} = 0$. Net spillovers play a crucial role in what follows. Indeed, we can reformulate (3.7) more compactly as

$$u_i^c(C) = \begin{cases} b_i - \lambda_i c_i + \sum_{j\in C} \sigma_{ij} & \text{if } i \in C, \\ \sum_{j\in C} \sigma_{ij} & \text{if } i \notin C. \end{cases} \tag{3.8}$$

The set C of projects is determined by voting in a legislature, as described below. The choice of C will generally not be efficient *i.e.* will not satisfy (3.3), as is discussed in detail in Section 4.2.

3.4. *Discussion*

Several features of our model merit comment at this stage. First, we have chosen to work with discrete regional public goods (projects). Discreteness is not unrealistic; many publicly funded infrastructure projects, such as airports, roads, universities, *etc.* are discrete, although there is often a range of options on the scale of the project. However, modelling variable scale gives rise to additional problems: when projects are non-binary (*i.e.* are variable in size), voting intransitivities over the space of alternatives with centralization become more serious, and it becomes correspondingly more difficult to find simple and unrestrictive[17] legislative rules that

16. Of course, if voters in a region had differing preferences over projects, then the choice of delegate would be non-trivial, and some explicit modelling of the procedure for the selection of a delegate would be appropriate. This issue is pursued in Besley and Coate (1997).

17. Of course, if the rules are restrictive enough, an equilibrium will always exist, even with projects with infinitely variable scale. For example, the legislative rules in the Baron–Ferejohn (1989) model define a game between legislators which has a unique solution in this case (see Section 7.2 for further discussion of this model).

will result in a determinate outcome (see Ferejohn, Fiorina and McKelvey (1987) for more discussion).

Second, following nearly all the literature[18] on decentralization, we have assumed that Coasian bargaining between regions to internalize externalities is impossible or prohibitively costly. In this context, there may be several reasons why this may be the case. For example, the external benefits may be very diffusely spread across the population, as may happen with infrastructure projects such as roads. Again, regional governments may not be well-informed about the external benefits accruing to their residents. Finally, there may be no enforceable mechanism for making side-payments at the regional level. An example here would be sulphur dioxide pollution crossing state boundaries in the U.S.

Turning to centralization, we have assumed that *relative* taxes across regions are fixed *i.e.* are not chosen by the legislature. While this significantly generalizes the usual assumption in the distributive politics literature of a uniform tax across regions, it is the main *ad hoc* assumption in the model, and as such, obviously needs some justification. The first justification is the following. In practice, individual tax*codes* (*e.g.* rates of tax, exemptions, *etc.*) set nationally *are* almost always uniform across regions; so *de facto* differential taxation of regions occurs only because of their differing demographic and economic structures. Second, as shown in Section 7.1, if relative taxes are *endogenous i.e.* chosen by the legislature, there are multiple Condorcet winning policies, each of them involving only one region paying the costs of *all* projects. So, in this case, we have multiple outcomes, none of them very plausible.

4. POLITICAL EQUILIBRIUM WITH CENTRALIZATION

4.1. *Legislative rules and political equilibrium*

The choice set of the legislature can be thought of as the set of subsets of N, $\mathcal{N}$, where choice of $F \in \mathcal{N}$ means that project i is funded iff $i \in F$. Also, we write $F \succeq G$ when at least as many voters strictly prefer F to G as G to F; that is, "$\succeq$" is the weak binary preference relation over $\mathcal{N}$ induced by majority voting.[19] The corresponding strict binary relation is denoted by $F \succ G$. Finally, we will take the *status quo* to be a situation with no project in any region, $F = \emptyset$: this is very natural if projects can only be built, not destroyed, as $\emptyset$ can be taken to incorporate all previous projects.

Say that an alternative $F \in \mathcal{N}$ is a *Condorcet winner in* $\mathcal{K} \subseteq \mathcal{N}$ if F cannot be defeated by any $G \in \mathcal{K}$ in a majority vote *i.e.* if $F \succeq G$, all $G \in \mathcal{K}$. Our space of alternatives is multi-dimensional, and so one might conjecture that in general, no Condorcet winner (CW) will exist in $\mathcal{N}$. In fact, in the special case of our model without externalities, it is well-known that generally, there is no CW in $\mathcal{N}$ (Ferejohn, Fiorina and McKelvey (1987)). Example 1 below shows that there will also generally be no CW with externalities.

So, we must assume that the legislature has some rules for structuring voting. Following Farquarson (1969) and Ferejohn, Fiorina and McKelvey (1987), we define an *agenda* to be a set of alternatives $\mathcal{A} = \{F_1, F_2, \dots, F_k\}$, $F_i \in \mathcal{N}$ together with a rule that specifies the way in which votes over the alternatives are taken. Without much loss of generality, we restrict attention to *amendment agendas* over $\mathcal{A}$. An amendment agenda is simply a permutation of the list of alternatives $(F_1, F_2, \dots, F_k)$, *i.e.* $(G_1, G_2, \dots, G_k)$, *plus* a sequence of $k-1$ votes or ballots. At the first ballot, all delegates vote on G_1 vs. G_2 and the winner (by majority vote) is then paired with G_3 in the second ballot, and so on. Finally, say that an agenda is an amendment agenda

18. An exception is Klibanoff and Poitevin (1996).

19. That is, $\#\{i \mid u_i^c(F) > u_i^c(G)\} \geq \#\{i \mid u_i^c(G) > u_i^c(F)\}$. Note that in defining this preference relation, we are assuming that voters who are indifferent between F, G abstain.

with *a distinguished status quo* if the status quo is added at the end of the list of alternatives *i.e.* $(G_1, \dots, G_k, \emptyset)$. Given $\mathcal{A}$, there again are $k!$ possible amendment agendas with a distinguished status quo. More formally, let $\pi : K \to K$, $K = \{1, \dots, k\}$ be a permutation function, and Π be the set of all such functions. So, following Banks (1985), any amendment agenda is characterized by a $\pi \in \Pi$; specifically, $\pi(i)$ is the position of alternative F_i on that agenda, so $G_1 = F_{\pi^{-1}(1)}$, $G_2 = F_{\pi^{-1}(2)}$ *etc.*

The legislative rules studied in this paper can then be described as follows:

Stage 1. Delegates $i \in N$ simultaneously propose sets $\mathcal{A}_i \subset \mathcal{N}$ of possible alternatives for consideration. The set of alternatives on the agenda is $\mathcal{A} = \cup_{i \in N} \mathcal{A}_i$, with $\mathcal{A} = \{F_1, F_2, \dots, F_k\}$.

Stage 2. Delegates vote in the $k - 1$ ballots in the amendment agenda $\pi \in \Pi$ with a distinguished status quo.

So, for a fixed π, our legislative rules comprise a k-stage game played by the delegates (the proposal stage, and the $k - 1$ ballots). We assume that weakly dominated strategies are not played in the voting subgame[20] of Stage 2. Call any subgame-perfect equilibrium of the game that satisfies this restriction a *political equilibrium*. The political equilibrium will imply a particular choice, C, of a set of projects to be funded, and we refer to C as the *political equilibrium outcome.* We take this to be the outcome under centralization.

The legislative rules described above are rather general. First, they are *complete* in the sense that we allow for endogenous choice of items to be placed on the agenda. Second, the structure of the agenda is quite general, in the sense that the alternatives (other than the status quo) can be on the agenda in *any* order. Third, as emphasized by Ferejohn, Fiorina and McKelvey (1987), the feature of the status quo being the last item on the agenda is found in almost all legislatures in practice. In practice, it arises when a bill is proposed, amendments to the bill are voted on, and finally the (possibly amended) bill is moved.

The second reason—apart from its empirical importance—why we assume a distinguished status quo is that without it, if there does not exist a CW in $\mathcal{A}$, it is well-known that the outcome of the voting subgame will depend on π in general (Banks (1985)), implying that the political equilibrium outcome may depend on the particular choice of amendment agenda (*agenda-dependence*). This is a very undesirable feature of the model, as we wish to have a prediction of the outcome under centralization that is independent of the detail of the legislative rules. The following result describes precisely to what extent a distinguished status quo eliminates the problem of agenda-dependence. Assume that no region is indifferent[21] between any two alternatives:

A0. $u_i^c(F) \neq u_i^c(G)$, all $i \in N$, $F, G \in \mathcal{N}$.

Finally, define $\mathcal{N}_\emptyset = \{F \in \mathcal{N} \mid F \succ \emptyset\}$ to be the set of those alternatives that beat the status quo. Then we have:[22]

Lemma 1. *If* A0 *holds, and* W *is the unique Condorcet winner in* $\mathcal{N}_\emptyset$, *then* W *is the political equilibrium outcome for all* $\pi \in \Pi$ i.e. *the political equilibrium outcome is agenda-independent.*

20. Note that in any political equilibrium, voters vote *non-myopically*, from the fact that the equilibrium is subgame-perfect. The subgame-perfect voting strategy profile is sometimes known as sophisticated voting (Banks (1985)).

21. Note that as F, G may only differ in one project other than $i's$, A0 implies that $\sigma_{ij} \neq \sigma_{ik}$ all $i, j, k \in N$ with $i \neq j \neq k$. We will also assume that $\sigma_{ij} \neq 0$ for convenience.

22. This, and all subsequent results, are proved in the Appendix, where a proof is required.

This lemma is a generalization of Theorem 1 of Ferejohn, Fiorina and McKelvey (1987) to the case of externalities, and endogenous agenda formation (*i.e.* stage 1 above). It says that a distinguished status quo eliminates agenda-dependence in environments when there is a unique CW in $\mathcal{N}_\emptyset$. The intuition is simple: first, if W is on the agenda, it is always the unique outcome of the voting subgame, as no other alternative can simultaneously beat W and the status quo. Given this, some voter always has the incentive to put it on the agenda at stage 1. For suppose not; then, the political equilibrium outcome will be some $F \neq W$. But F must also be weakly preferred to the status quo *i.e.* be in $\mathcal{N}_\emptyset$. So, as W is the unique CW in $\mathcal{N}_\emptyset$, it must be true that $W \succ F$, implying that at least one voter prefers W to F. This voter then has an incentive to propose W at stage 1.

Our next task is to find conditions that will ensure that there is a unique CW in $\mathcal{N}_\emptyset$ and to characterize this CW. Less interested readers may skip directly to Section 4.3.

4.2. *Conditions for a unique Condorcet Winner in $\mathcal{N}_\emptyset$*

We begin by making two quite weak assumptions. The first says that each region derives a greater benefit from its project than its share of the cost under centralization:

A1. $b_i > \lambda_i c_i,\ i \in N$.

Next, take two regions i, j. We assume that i gets a positive net spillover from a third region k iff j does *i.e.* all regions agree on the *sign* of net spillovers from projects:

A2. $\sigma_{ik} > 0 \Leftrightarrow \sigma_{jk} > 0$, all $i, j, k \in N$ with $i \neq j \neq k$.

As the cost-sharing spillover is negative, A2 is automatically satisfied if all externalities are non-positive *i.e.* $e_{ij} \leq 0$. We can now define $N^+ = \left\{ j \in N \left| \sigma_{ij} > 0,\ \forall i \neq j \right. \right\}$ to be the set of regions which all regions agree have positive net spillovers, and let $\#N^+ = n^+$. Also, let $m = (n+1)/2$. Our first result is:

Lemma 2. *Assume that A0–A2 hold. Then if $n^+ \geq m$, N^+ is the unique Condorcet winner in $\mathcal{N}$ (and therefore $\mathcal{N}_\emptyset$).*

The intuition here is simple. As the net spillover from every project in N^+ is positive, *every* region prefers N^+ to some proposal that gives projects to fewer regions. Also, a majority of regions (*i.e.* all $i \in N^+$) prefer N^+ to a proposal that gives projects to more regions, as the net spillover from any project in $j \notin N^+$ is negative. Consequently, N^+ beats every other alternative in $\mathcal{N}$. This result does *not* generalize to the case where only a minority of the projects have positive net spillovers ($m > n^+ > 0$), as the following example shows.

Example 1. Assume $n = 3, \lambda_i = \frac{1}{3},\ e_{ij} = 0{\cdot}5, i \neq j$, and $c_1 = 1, c_2 = 2, c_3 = 3,\ b_i = 2$. So, net spillovers are $\sigma_{ij} = 0{\cdot}5 - c_j/3,\ j \neq i$, implying $\sigma_{i1} = \frac{1}{6},\ \sigma_{i2} = -\frac{1}{6},\ \sigma_{i3} = -\frac{1}{2}$. So $N^+ = \{1\}$, and thus $n^+ = 1 < 2 = m$. Now, from (3·8), payoffs from any set F of funded projects are

$$u_i^c(F) = \begin{cases} 2 - c_i/3 + \sum_{j \in F} \sigma_{ij} & \text{if } i \in F, \\ \quad - \sum_{j \in F} \sigma_{ij} & \text{if } i \notin F\cdot \end{cases} \tag{4.1}$$

Define the non-empty alternatives in $\mathcal{N}$ as: $N = \{1, 2, 3\},\ \ A = \{1, 2\},\ \ B = \{1, 3\},\ \ E = \{2, 3\},\ \ N^+ = \{1\},\ \ F = \{2\},\ \ G = \{3\}$. Then it is easy to check using payoffs in (4.1) that regions 1, 2, 3 have the following rankings over $\mathcal{N}$:

$$1 : N^+ \succ_1 A \succ_1 B \succ_1 N \succ_1 \emptyset \succ_1 F \succ_1 G \succ_1 E,$$
$$2 : A \succ_2 F \succ_2 N \succ_2 E \succ_2 N^+ \succ_2 \emptyset \succ_2 B \succ_2 G,$$
$$3 : B \succ_3 N \succeq_3 G \succ_3 E \succ_3 N^+ \succ_3 A \succeq_3 \emptyset \succ_3 F.$$

Then the set of those alternatives that beat the status quo in majority vote is

$$\mathcal{N}_\emptyset = \{G \in \mathcal{N} \mid G \succ \emptyset\} = \{A, B, E, N^+, N\}.$$

It is then straightforward to check that given the above rankings, there is no CW in $\mathcal{N}_\emptyset$. First, as externalities are uniform, no alternative with two projects that does not minimize total project cost can be a CW *i.e.* $A \succ B, E$. Finally, there is a cycle in the remaining alternatives in $\mathcal{N}_\emptyset$: $N^+ \succ A \succ N \succ N^+$.

Intuitively, the voting cycle in $\mathcal{N}_\emptyset$ arises for the following reason; only project 1 has a positive net spillover, so on externality grounds, a majority of delegates all prefer just this one project to be funded, rather than two projects, and two projects, rather than three, but projects 2 and 3 have high benefits for the regions concerned, so a majority also prefer all projects to be funded.

The example also makes clear however, that the only way that this cycle can be avoided is by making *either* delegate 2 or delegate 3 prefer $N^+ = \{1\}$ to $N = \{1, 2, 3\}$, for example[23], by lowering b_2 or b_3. For then, as delegate 1 prefers N^+ to N, we would have $N^+ \succ N$, breaking the cycle and making N^+ the CW. The following assumption extends this reasoning to the general case:

A3. If $1 \leq n^+ < m$, then for any L such that $\#L = l \geq m$, at least $l - (m - 1)$ of the delegates $i \in L$ strictly prefer N^+ to L.

Assumption A3 ensures that when a majority of net project spillovers are negative, within-region benefits are not so high so that any majority of regions all prefer projects in their regions to be funded in preference to the set N^+ of projects. It is easily checked[24] that in Example 1 above, A3 reduces to the requirement that either delegate 2 or delegate 3 prefer N^+ to N.

Given A3, we can now show that a CW emerges even when $n^+ < m$:

Lemma 3. *If* $1 \leq n^+ < m$*, and in addition A0–A3 hold, then* N^+ *is the unique Condorcet winner in* $\mathcal{N}$*.*

Note however, that under the conditions of Lemma 3, projects are only funded in a minority of regions (and possibly only one!).

We now turn to the case where all projects have negative spillovers ($n^+ = 0$). Here, we assume that all regions have the same *ordinal* ranking of net spillovers *i.e.*

A4. $\sigma_{ik} > \sigma_{il} \Leftrightarrow \sigma_{jk} > \sigma_{jl}$, all $(i, j), (k, l) \in N \times N$ with $i, j \neq k, l$.

23. For $i = 2, 3$ to prefer N^+ to N, we need either $b_2 - 2/3 + 1/6 - 1/2 < 1/6$, or $b_3 - 1 + 1/6 - 1/6 < 1/6$, which reduce to $b_2, b_3 < 7/6$.

24. Note that in the example, $L = A, B, E$ or N. In the first case, when $l = 2$, at least $2 - (2 - 1) = 1$ delegates in $L = A, B, E$ must strictly prefer $N^+ = \{1\}$ to L. By the argument in Example 1, N^+ is preferred by a majority to A, B, E so this certainly holds. In the second case, when $l = 3$, at least $3 - (2 - 1) = 2$ delegates in $N = \{1, 2, 3\}$ must strictly prefer $N^+ = \{1\}$ to N. By the argument in Example 1, N^+ is preferred by delegate 1 to N. So, A3 requires that one of delegates 2, 3 prefer N^+ to N.

Note that this is automatically satisfied if $n = 3$. Given A4, we can define unambiguously the m regions with the net spillovers that are least damaging for other regions. Without loss of generality, order the regions by decreasing net spillover *i.e.* $i < j \Leftrightarrow \sigma_{ki} > \sigma_{kj}$ for all $i, j, k \in N$ with $i \neq j \neq k$. By A2, A4, this ordering is well-defined and unique. Then let $M = \{1, 2, \ldots, m\}$. For example, if there are no externalities ($e_{ij} = 0$), M is simply the set of m regions with lowest project costs, as then $\sigma_{ki} = -\lambda_k c_i$.

Our next assumption just says that all regions $i \in M$ strictly prefer alternative M to the *status quo*. Formally, using (3.8), this requires:

A5. $b_i - \lambda_i c_i + \sum_{j \in M} \sigma_{ij} > 0, \ i \in M.$

Assumption A5 places a lower bound on the spillovers between members of M, or conversely, on the b_i. For example, if there are no externalities ($\sigma_{ij} = -\lambda_i c_j$) then A5 just requires $\min_{i \in M}(b_i/\lambda_i) > \sum_{j \in M} c_j$. Then we have:

Lemma 4. *Assume that A0–A2, A4, A5 hold. If $n^+ = 0$, then there is no Condorcet winner in $\mathcal{N}$, but M is the unique Condorcet winner in $\mathcal{N}_\emptyset$.*

The intuition is as follows. First, when net spillovers from *all* projects are negative, the proposal M beats any proposal that gives projects either to more regions, or to a different set of m regions. But, nevertheless, M cannot be a CW, as it is beaten—for example—by a proposal that only gives a project to regions in a subset of M. But, this last proposal imposes a negative net spillover on a majority of regions, and so is then beaten by the *status quo.*

Finally, we comment on Assumptions A0–A5. First, note that Assumptions A0, A1, A2 are needed for all results, whereas A3 is needed for Lemma 3, and Assumptions A4, A5 are needed for Lemma 4. Example 1 shows why A3 is required. Assumption A0 holds generically. Assumptions A4, A5 could be relaxed somewhat, but at the cost of greater complexity (see Lockwood (2001)). This leaves Assumptions A1, A2. An Example in Appendix A.1 shows that when A2 is violated, generally, there may not be a CW even in $\mathcal{N}_\emptyset$, the set of those alternatives that are not beaten by the status quo. Assumption A1 is made for convenience only.

Taken together, these assumptions still allow a reasonably rich structure of externalities. For example, A0–A2, A4, A5 are consistent with the case of negative "atmospheric" externalities, such as greenhouse gas emissions, under certain parameter restrictions. Suppose that a project in region j emits amount $\delta_j > 0$ of greenhouse gasses, and the damage to region i from aggregate emissions is $\alpha_i \sum_{j \in F} \delta_j$. In this case, $e_{ij} = -\alpha_i \delta_j$, and, assuming equal cost-sharing, $\sigma_{ij} = -(\delta_j + c_j/n)$. Then, A2 is automatically satisfied, and A5 is also satisfied if $\alpha_i \simeq \alpha_j$.

4.3. *The outcome with centralization*

We can now combine Lemmas 1–4 as follows. Lemmas 2–4 assert that if A0–A5 hold, the conditions of Lemma 1 are satisfied when $W = N^+$ or $W = M$ as appropriate, so we have:[25]

Proposition 1. *If A0–A5 hold, then there is a unique political equilibrium outcome C, where $C = N^+$ if $n^+ \geq 1$, and $C = M$ if $n^+ = 0$.*

25. Note that, we only need a distinguished status quo in the case of negative spillovers. As a "global" CW exists with at least one positive spillover, in that case voting over *any* agenda would yield $C = N^+$.

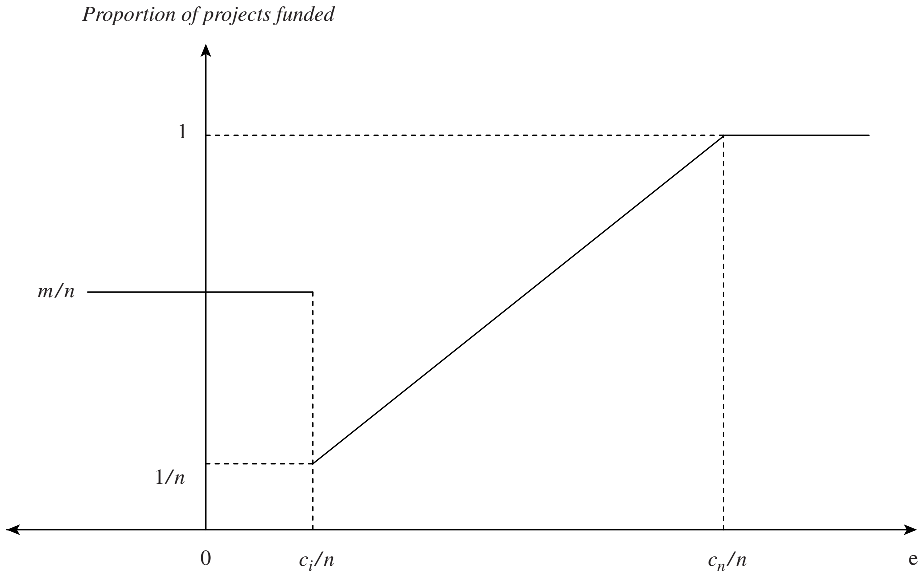

FIGURE 1

The proportion of projects funded when externalities are uniform. Note: bold line denotes the proportion of projects funded as a function of e

Proposition 1 has the following striking implications.[26] First, it is clear from the definitions of N^+, M that we have *benefit-insensitivity* of the outcome; specifically, the set of projects undertaken in political equilibrium, being N^+ or M, is determined entirely by the spillovers, and is thus *independent* of the local benefits b_i of the projects (subject to A1, A4 being satisfied). This makes precise the idea, expressed in Oates (1972) and elsewhere, that centralization means that decisions are less responsive to regional preferences.

A second implication is clearest when we assume that externalities are *uniform i.e.* $e_{ij} = e$, $i, j \in N$, $j \neq i$ and cost shares are equal *i.e.* $\lambda_i = 1/n$, $i \in N$. In this case, w.l.o.g. order the regions by increasing project cost *i.e.* $c_1 < c_2 < \dots c_n$ (no two project costs can be the same by A0). Then, clearly, $N^+ = \{i \in N \mid e - c_i/n > 0\}$. So, if $c_{k+1}/n > e > c_k/n$, then $N^+ = \{1, 2, \dots k\}$, so exactly k lowest-cost projects will be funded in political equilibrium. Also, if $e < c_1/n$, the m lowest-cost regions will get projects. So, it is clear that the number of projects funded, $\#C = c$, is *non-monotonic* in the size of the externality, as is shown in Figure 1. Specifically, when the spillover is of intermediate size, (*i.e.* $c_1/n < e < c_m/n$), c actually falls. As remarked above, the intuition is that with intermediate externalities, *all* regions may prefer the funding of projects in a few very low-cost regions to the *status quo*, whereas when externalities are very low (or zero) the *status quo* can only be defeated by a "minimum winning coalition".

26. This result extends Theorem 1 of Ferejohn, Fiorina and McKelvey (1987) in two directions. First, we allow for project spillovers, and second, we allow for endogenous agenda formation. In our setting, their result was that with $e_{ij} = 0$, proposal M is the unique outcome of the voting subgame described in 4.1 above, whatever other motions were on the agenda.

4.4. *Political economy vs. policy uniformity*

We can compare this political equilibrium to the outcome in our model under Oates' assumptions of policy uniformity and a benevolent social planner. Here, policy uniformity requires that either all projects are undertaken, or none of them are. So, as utility is transferable, a social planner would opt for all projects ($F = N$) over no projects iff the sum of utilities from $F = N$ is positive *i.e.*

$$\sum_{i \in N} (b_i - c_i) + \sum_{i \in N} \sum_{j \in N} e_{ij} \geq 0.$$

Because projects are discrete, policy uniformity would appear very suboptimal. However, it is easy to show (along the lines of the examples in Section 5 below) that under some conditions, it may yield higher surplus than both the outcome of the political equilibrium under centralization, and decentralization. In particular, policy uniformity is sensitive to benefits in a way that the political economy outcome with centralization is not.

5. WHEN IS DECENTRALIZATION MORE EFFICIENT?

Now that we have characterized the outcome of the political process with centralization, we are in a position to assess the relative efficiency of centralization and decentralization. The earlier literature usually defines efficiency in the sense of the maximization of aggregate surplus *i.e.* sum of utilities.[27] The informal conclusions of this literature are that decentralization yields a higher level of surplus than does centralization if (i) inter-regional externalities are small; (ii) regions are relatively heterogenous. For example, on (ii) Oates (1972, p. 37) says: "the welfare gain from the decentralized provision of particular local public good becomes greater as the diversity of individual demands within the country as a whole increases".

In this section, we investigate whether these results carry over to our model. It is not obvious that this should be so, as here the cost of centralization is not policy uniformity, but rather insensitivity of decision-making to project benefits. We find that while conditions can be found under which both statements are true, there are some important qualifications, especially in the case of heterogeneity. We also consider an alternative and stronger definition of efficiency. If the aggregate surplus is greater under decentralization, then decentralization is unambiguously *potentially* Pareto-preferred. But this is only of interest if lump-sum transfers between regions are possible at the point where the choice between centralization and decentralization is made. So, we also investigate under what conditions (de)centralization is Pareto-preferred without lump-sum transfers *i.e.* unanimously preferred.

5.1. *When is decentralization potentially Pareto-preferred to centralization?*

Denote by W^d, W^c the aggregate surplus (sum of utilities) from decentralization and centralization respectively. The following way of writing these surpluses is illuminating. First, from (3.4), we see that

$$W^d = \sum_{i \in N} \max\{b_i - c_i, 0\} + \sum_{i \in N} \sum_{j \in D} e_{ij}.$$

Also, after simple arrangement of (3.7),

$$W^c = \sum_{i \in N} x_i^C (b_i - c_i) + \sum_{i \in N} \sum_{j \in C} e_{ij},$$

27. For this to be well defined, individual utilities must be linear in income (transferable utility). This is usually the case in the formal modelling, as it is in this model.

where $x_i^C = 1$ iff $i \in C$. So, the gain in aggregate surplus is

$$W^d - W^c = \sum_{i\in N}[\max\{b_i - c_i, 0\} - x_i^C(b_i - c_i)] + \sum_{i\in N}\left(\sum_{j\in D} e_{ij} - \sum_{j\in C} e_{ij}\right). \quad (5.1)$$

The first term in (5.1) captures the fact that decentralization is always more responsive to regional net benefits from projects, and is always non-negative.

The second term involving project spillovers only, may be positive or negative. Decentralization is inefficient here in the sense that project externalities are not internalized at all (D does not vary with the e_{ij}). Centralization may be more efficient as project externalities are *partially internalized* through the legislative process (from Proposition 1, C is increasing in the number of projects with positive net spillovers as long as $n^+ > 0$).

We first turn to the question of when decentralization or centralization is the more efficient. First, we can prove the following:

Proposition 2. *Assume that A0–A5 hold. If there are no project spillovers ($e_{ij} = 0$), then decentralization is more efficient ($W^d \geq W^c$) and strictly so unless $D = M$. If project spillovers are positive and large enough in the sense that $D \subseteq N^+$, then centralization is more efficient ($W^d \leq W^c$) and strictly so unless $D = N^+$.*

This result establishes that when project spillovers are zero, decentralization is more efficient, but when project spillovers are large and positive (in the sense that the number of projects with positive net spillovers exceeds the number of projects funded under decentralization), centralization is more efficient. Note there is an asymmetry here—it is not generally the case that centralization is more efficient when project spillovers are large and negative.

One might conjecture from this result that the gain to centralization would be *everywhere* non-decreasing in the number of projects with positive externalities. In fact, this is not the case, as the following example shows. The intuition is related to the non-monotonicity of the number of projects in e discussed above in the case of uniform externalities; specifically, in the example, an increase in the externality may *reduce* the set of projects funded with centralization, while (by definition), leaving the set of projects funded under decentralization unchanged.

Example 2. The example has five regions. We assume uniform externalities, equal cost shares, $c_1 = 1$, $c_2 = 1 + \varepsilon$, $1/5 > \varepsilon > 0$, $c_3 = 3$, $c_4 = 4$, $c_5 = 5$, $b_1 = b_2 = b_4 = b_5 = 6/5$, $b_3 = 29/10$. So, costs and within-region benefits are such that $D = \{1, 2\}$. To analyse the case with centralization, we first proceed on the assumption that A0–A5 are satisfied, and then check that this is the case.

Recall that $\sigma_{ij} = \sigma_j = e - c_j/n$. Initially $e = 1/10$. So as $e < c_1/5$, $\sigma_j < 0$, all $j \in N$, so $n^+ = 0$, and from Proposition 1, $C = \{1, 2, 3\}$. Then

$$W^c - W^d = b_3 - c_3 + 4e = -0{\cdot}1 + 4\,(0{\cdot}1) > 0,$$

i.e. centralization is strictly more efficient. Now let e increase to $e' = 1/5 + \delta$ so that $c_2/5 > e' > c_1/5$, so $n^+ = 1$. Then, assuming A3 is satisfied, from Proposition 1, $C = \{1\}$, so now

$$W^c - W^d = -4e' - (b_2 - c_2) = -1 - 4\delta + \varepsilon < 0.$$

So, in this example, $W^c - W^d$ is *not* everywhere non-decreasing in e.

It remains to show that A0–A5 hold in this example for both values of e. It is clear that A1 holds, and A0 holds as long as $e \neq c_i/5$. As externalities are uniform, A2, A4 are satisfied. A5 requires $b_i + 2e \geq 1 + \varepsilon/5,\ i = 1, 2, 3$, which clearly holds. Finally, it can be shown (proof on request) that A3 is satisfied.

We now turn to investigate whether decentralization becomes more desirable as regional characteristics become more heterogenous. The first issue is how to measure heterogeneity. As regions differ in cost and benefit characteristics, at first sight a natural definition of increased heterogeneity might be a mean-preserving spread (MPS) in *either* the distribution of benefits, *or* costs, or both, across regions. However, a moment's reflection indicates that it is heterogeneity of the *net* project benefits, $v_i = b_i - c_i$ that is important in Oates's argument cited above; for if all regions have the same net benefit, there is no efficiency loss from policy uniformity, no matter how the gross benefits, or the costs, of projects vary across regions. Indeed, if we measure heterogeneity in terms of net benefits, we can obtain a result, albeit under some stringent conditions. We will assume:

A6. $\{v_k\}_{k\in N}$ is symmetrically distributed around zero.

Also, define a *symmetric* mean-preserving spread of $\{v_k\}_{k\in N}$ to be an MPS of this distribution that results in a symmetric distribution with mean zero. We will of course, only consider the class of symmetric MPSs such that assumptions A0–A5 are satisfied both before and after the change.[28] Then we have:

Proposition 3. *Assume that A0–A6 hold, and that either (i) $e_{ij} < 0$ all $i, j \in N$ or (ii) costs c_i remain fixed. Then the efficiency gain from decentralization, $W^d - W^c$, does not fall following a symmetric MPS in the distribution of the net project benefits $\{v_k\}_{k\in N}$.*

The intuition behind this result is as follows. Assumption A6, plus the construction of the MPS, implies that net benefits do not change sign following the MPS; they rise (fall) only in regions where they were initially positive (negative). So, the set of projects funded under decentralization, D, is unchanged following the MPS. Also, (i) or (ii) implies that the set of projects funded under centralization, C, is unchanged following the MPS. Finally, the fact that net benefits rise (fall) only in regions where they were initially positive (negative) implies that the gain in "responsiveness" *i.e.* the first term in (5.1) cannot fall—and will usually rise.

Perhaps the most restrictive condition in Proposition 3 above is that net benefits are symmetrically distributed with mean zero. However, both parts of this condition are necessary, in that it is possible to find examples where a symmetric MPS in net benefits leads to a *fall* in the gain from decentralization when either part of the condition is relaxed.

Example 3. Suppose that there are three regions ranked by increasing cost ($c_1 < c_2 < c_3$) with $v_1 = v - \delta$, $v_2 = v > 0$, $v_3 = v + \delta$, (so that net benefits are symmetrically distributed, but with positive mean) and $v - \delta > 0$ initially, and that externalities are uniform, with $e > c_3/3$, and finally that cost shares are equal. So, it is efficient to fund all three projects. That is also initially the outcome under centralization; $C = \{1, 2, 3\}$ as $e > c_3/3$, from Proposition 1. It is also the outcome under decentralization, as $v_i > 0$, $i = 1, 2, 3$. Now increase δ (this is a symmetric MPS in the distribution of net benefits), so that $-2e < v - \delta < 0$, and suppose that this change takes place through changes in project benefits only. Then, project 1 is no longer funded under decentralization, although it is still efficient (as $v_1 + 2e > 0$). As neither costs, nor the size of

28. In the case of uniform externalities, the main requirement is from A5 that $v_i > \frac{m}{n}\sum_{j\in M} c_j - c_i - (m-1)e = \underline{v}_i$, $i \in M$. But as long as $\underline{v}_i < 0$, $i = 1, \ldots, m-1$, A5 is consistent with A6.

the spillover, e, have changed, centralization is still efficient, as before. So, now decentralization is less efficient than centralization.

Now modify the example so that $v_1 < v_2 = 0 < v_3$, *i.e.* net benefits have mean zero, but are no longer necessarily symmetrically distributed. Suppose also that $v_1 + 2e > 0$ so it is efficient to fund all projects. Initially, the set of projects funded under decentralization is $D = \{2, 3\}$. Now consider a (non-symmetric) MPS with v_2 changing to $-\delta$, with $\delta < 2e$ and v_3 changing to $v_3 + \delta$, with the change taking place through changes in benefits only. Then following the MPS, only the project in region 3 is funded with decentralization, but it is still efficient to fund project 2 (as $-\delta + 2e > 0$). So decentralization becomes less efficient. But by the previous argument, centralization is just as efficient as before.

These examples indicate that Proposition 3 is unlikely to generalize significantly. So, the belief that "increased heterogeneity" leads to increased relative efficiency of decentralization is not generally confirmed by this model. The underlying reason is that in our model, the cost of centralization is not policy uniformity, but lack of responsiveness of decision-making to project benefits.

5.2. *When is decentralization actually Pareto-preferred to centralization?*

Proposition 2 above implies that when project externalities are zero, decentralization is more efficient than centralization according to the aggregate surplus criterion, but when project externalities are large and positive, the reverse is the case. One might conjecture that there must be some way of choosing the remaining parameters (the b_i and c_i) so that *all* agents can share in the relevant efficiency gain *i.e.* so that decentralization is *unanimously* preferred when the spillover is zero, and centralization is *unanimously* preferred when it is large and positive. Surprisingly, it turns out that only the second half of this conjecture is true. Moreover, the condition required for it to be half-true is that both project benefits and project costs (not just net benefits) are sufficiently homogenous.

Say that the regions are *ε-homogenous* if there exists a number $\varepsilon > 0$ such that

$$|b_i - \overline{b}| < \varepsilon, |c_i - \overline{c}| < \varepsilon, \qquad \text{all } i \in N,$$

where $\overline{b} = \frac{1}{n}\sum_{i \in N} b_i$, $\overline{c} = \frac{1}{n}\sum_{i \in N} c_i$ are average project benefit and cost respectively. We assume that $\overline{b} \neq \overline{c}$. Finally, define $u_i^c \equiv u_i^c(C)$, where C is defined as in Proposition 1. We then have:

Proposition 4. *Assume A0–A5 hold. If all projects have positive net spillovers ($n^+ = n$), and $D \neq N$, then, there exists an $\varepsilon_0 > 0$ such that if the regions are ε-homogenous, with $\varepsilon_0 > \varepsilon$, then centralization strictly Pareto-dominates decentralization ($u_i^c > u_i^d, i \in N$). But, even if all projects have no spillovers ($e_{ij} = 0$), then decentralization never Pareto-dominates centralization ($u_i^c > u_i^d$, some i) if costs are sufficiently equally shared ($1/n \leq \lambda_i < 1/m$, all $i \in N$).*

Note first the striking result that even if there are no spillovers, *some* region will strictly gain from centralization, so the choice of decentralization can never be unanimous.[29] This is

29. In fact, with equal cost shares ($\lambda_i = 1/n$), the last result in Proposition 4 can be strengthened to the following: if externalities are non-positive ($e_{ij} \leq 0$), or all projects funded under decentralization are also funded under centralization ($D \subseteq C$), $u_i^c > u_i^d$, some $i \in N$. So, in these cases, decentralization never Pareto-dominates centralization (see Lockwood (1998) for details).

because the gain though cost-pooling will always benefit some high-cost region. Second, we see that with sufficient homogeneity across regions, and strongly positive externalities, centralization is Pareto-preferred.

6. CONSTITUTIONAL DESIGN

At some initial constitutional design stage, regions choose between centralization and decentralization. In practice, constitutional (re)design occurs through the political process, via what Buchanan (1987) calls constitutional rules. Depending on the nature of the constitution, reallocation of tax and spending powers may be decided upon by ordinary legislation in a national parliament, or may[30] require formal constitutional amendment, which may in turn, require referenda. In unitary states, such referenda may be only national, such as the 1975 referendum in the U.K. to decide on membership of the European Union. However, in truly federal states, constitutional amendment always requires, in some way or other, approval of a (super)majority of the constituent states or regions.[31]

In this model, as all voters in a given region are identical, and all regions have identical populations, constitutional rules of this type reduce to a simple regional referendum: regions (or their delegates) vote on the *status quo* vs. the alternative, and the *status quo* is selected unless a proportion[32] of at least α of regions prefer the alternative. We focus on two special cases; ordinary majority rule ($\alpha = 0{\cdot}5$), and unanimity rule ($\alpha = 1$). We focus on the extent to which Proposition 4 above extends to these two alternative decision rules.[33] At this stage, we do not specify whether the *status quo* is centralization or decentralization.

6.1. *Majority rule*

With majority rule, (de)centralization is selected if (of the regions that are not indifferent) a majority strictly prefers (de)centralization. In this case, it is possible to find conditions, on the distribution of costs only[34], sufficient for decentralization to be chosen when project externalities are zero, and for centralization to be chosen when externalities are large. Say that costs are ε-*homogenous* if there exists a number ε such that $|c_i - \overline{c}| < \varepsilon$, all $i \in N$, where $\overline{c} = \frac{1}{n}\sum_{i \in N} c$. Also, let β_m be the median benefit in the distribution of benefits across regions. We have:

Proposition 5. *Assume* A0–A5 *hold and* $\lambda_i = 1/n$, $i \in N$. *If there are no externalities* ($e_{ij} = 0$), *and costs are sufficiently heterogenous* ($c_1 < \frac{1}{n}\sum_{j=1}^{m} c_j$) *then majority rule selects decentralization, whatever the status quo. If all projects have positive net spillovers* ($n^+ = n$), $\beta_m > \overline{c} + \sum_{j \in N/D} e_{ij}$, *and* $d \neq m \neq n$, *then there is an* $\varepsilon_0 > 0$ *such that if costs are* ε-*homogenous, with* $\varepsilon_0 > \varepsilon$, *then majority rule selects centralization, whatever the status quo.*

30. Constitutional amendments are used routinely in Switzerland, and less frequently in the U.S., Canada and Australia, to reallocate tax and spending powers (Wheare (1963)).

31. Constitutional amendments in Australia and Switzerland require majority approval of the population as a whole, and also majorities in all the regions (cantons), but in the U.S., approval of a supermajority ($3/4$) of the states is required (Wheare (1963)).

32. In the event of a tie, we assume that the status quo is selected, which we take w.l.o.g. to be decentralization.

33. Of course, to the extent that constitutional revision is costly or infrequent, regions will take an *ex ante* view of project costs and benefits, and so from this perspective, regions will be more homogenous than at the stage when projects are actually chosen. In the extreme case, one can imagine all regions are *ex ante* identical, in which case (assuming that behind the veil of ignorance, agents evaluate lotteries according to the expected utility criterion, Harsanyi (1953)), agents will simply choose the alternative that maximizes the expected value, or equivalently the sum, of utilities. In this case, every region would choose decentralization iff $W^d \geq W^c$ under both unanimity and majority rules, in which case decentralization or centralization would be selected given the relevant conditions in Proposition 2.

34. Plus a weak lower bound on the median benefit.

For the case of large positive externalities, this result can be contrasted with Proposition 4: whereas we needed homogeneity in *both* costs and benefits to get a result about unanimous preference, we need only homogeneity in costs and a weak condition on the median benefit to get a result about majority preference.

6.2. *Unanimity rule*

In this case, we can state some results as simple corollaries of Proposition 4. First, if $e_{ij} = 0$, and if the *status quo* is centralization, then the *status quo* will *never* be defeated. Conversely, if the *status quo* is decentralization, then it will be defeated only if externalities are strongly positive ($n^+ = n$) and preferences are sufficiently homogenous. So unanimity rule gives a very strong advantage to the *status quo* in our setting.

7. SOME EXTENSIONS AND APPLICATIONS

7.1. *Endogenous taxes*

If taxes are endogenously chosen by the legislature, the legislature votes over the expanded set of alternatives where taxes are unrestricted except that they must achieve budget balance *i.e.*

$$S = \left\{(t_1, \dots, t_n, F) \;\middle|\; \sum_{i=1}^{n} t_i \omega_i = \sum_{i \in F} c_i,\ F \subset N,\ t_i \in \Re \right\}.$$

The obvious (and well-known) problem here is that *whatever* the restrictions on externalities e_{ij}, there can be no CW in S. To see this, fix a set of projects F, let $S(F)$ be the subset of alternatives where F is fixed, and consider some $s \in S(F)$. Then s can obviously be beaten by $s' \in S(F)$ where in s', the taxes for a majority of regions in s are cut by ε and the taxes of the remaining regions raised to balance the budget. The same argument obviously applies even if we restrict attention to $S_{\emptyset}$, the subset of alternatives that beat the *status quo* in a majority vote.

One obvious objection to this argument is that it relies on the fact that there is no lower bound on taxes. For example, suppose that we require $t_i \geq 0$ to prevent regions paying themselves subsidies financed by taxes on other regions. Then, it is possible to show that for a fixed F, there are n Condorcet winners in $S(F)$, each of them involving complete expropriation of one region *e.g.* $t_i \omega_i = \sum_{i \in F} c_i$, $t_j = 0,\ j \neq i$ if i is expropriated.

Assuming region i to be expropriated, *i.e.* restricting attention to proposals in $S_i = \{(t_1, \dots, t_n, F) \mid t_i \omega_i = \sum_{i \in F} c_i,\ F \subset N,\ t_j = 0,\ j \neq i\}$, one can then define net project spillovers as: $\sigma_{ij} = e_{ij} - c_j,\ \sigma_{kj} = e_{kj},\ k \neq i$, and relative to these spillovers, Lemmas 2–4 continue to hold given the Assumptions A0–A5. So, given these assumptions, there will be a unique CW s_i in the subset of S_i preferred by a majority of voters to the status quo. So, overall, there will be n CWs $(s_1, \dots, s_n)$ in the subset of S preferred by a majority of voters to the status quo, where the ith CW has region i funding all projects. So, even with “reasonable” lower bounds on taxes, there will be no determinate outcome with majority voting.

So, with differentiated taxes, some much stronger structure must be imposed on majority voting to ensure a determinate outcome. One such structure would be the legislative bargaining game of Baron and Ferejohn discussed below.[35] It is, however, easy to show that in the one-shot closed rule version of the game with differentiated taxes, and assuming a lower bound on the taxes to ensure existence, the agenda-setter can use the differentiated taxes to extract all

35. A rather different approach to the non-existence of CWs when unrestricted transfers between voters is possible has been taken by Myerson (1993) and Lizzeri and Persico (2001). They work with a Downsian framework where two office-motivated parties can choose transfers between voters. Due to the non-transitivity of majority rule, there is no political equilibrium, but equilibrium is restored if randomization over transfers is allowed.

the surplus from the other regions, and so effectively becomes a social planner, choosing the efficient (surplus-maximizing) set of projects. So, in this setting, the Baron–Ferejohn model is "too" restrictive *i.e.* it ensures a determinate outcome with differentiated taxes, but does not allow it to be inefficient.

7.2. *Alternative models of legislative behaviour*

In structuring majority voting, we have assumed a two-stage process; first, a (binary) agenda is formed, and then voting takes place. The other leading model of legislative behaviour is the Baron and Ferejohn (1989) model of legislative bargaining, which has been applied to public finance issues by Persson (1998), Persson, Roland and Tabellini (2000) amongst others. This model imposes much stronger restrictions on the behaviour of the legislature than we have made in this paper. This is clear if we consider the "one-shot" closed-rule version of the Baron/Ferejohn model that has been used by other authors in public finance settings. In this version, each legislator is chosen with probability $1/n$ to make a proposal which is then voted on in a pairwise comparison with the *status quo*, after which the game ends. This is in contrast to our procedure, where *all* agents can make proposals, which are then voted on sequentially.

A second problem with the Baron/Ferejohn model—other than its restrictiveness—is that it is possible that even when a Condorcet winner exists, alternatives other than the CW alternative will be chosen in equilibrium. The reason is that the legislator who is selected to make a proposal then chooses her proposal to maximize her payoff, subject to the constraint that at least $m - 1$ other legislators also prefer that proposal to the *status quo*, and the solution to this constrained maximization problem need not be a CW.[36] An example illustrating this point is given in Lockwood (1998). In general, however it is possible to show that this divergence between the CW outcome and the Baron/Ferejohn equilibrium outcome is negligible when n is large (Proposition 9 in Lockwood (1998)).

7.3. *Vote-trading*

It is often asserted that legislators have an opportunity[37] for "vote trading", that is, an agreement between two or more legislators for mutual support, even though it requires each to vote contrary to his real preferences on some legislation (Ordeshook (1986)). A standard way of modelling vote-trading is to suppose that legislators can form coalitions to coordinate their strategies. Associated with any coalition $S \subset N$ is a *characteristic function i.e.* a set of feasible utility vectors for that coalition. In our model (given the agenda-setting and voting procedure described in Section 4.1 above), the set of feasible utility vectors for S is defined as the set that S can guarantee themselves by coordinating their agenda-setting and voting behaviour. Then, given the characteristic function, the core of the voting game can be defined, and a point in the core (if the core is non-empty) is an equilibrium with vote-trading.

More formally, say that $F^* \subset N$ is an *equilibrium with vote-trading* if no coalition of delegates S can form, and by co-ordinating their votes, achieve an alternative outcome G which is strictly preferred to F^* by all $i \in S$. Then it is easy to prove[38] the following. Assuming that A0–A3 hold, if $n^+ > 0$, then $F^* = N^+$ is the unique equilibrium with vote-trading.

36. In particular, the proposer may wish to grant herself a project, even though a majority of other delegates may prefer the proposer *not* to have a project.

37. If the legislators could make monetary side-payments in exchange for votes, this could be analyzed in the same way, and we would find that the efficient (surplus-maximizing) set of projects would be the unique choice. In practice, of course, paying for votes is usually illegal.

38. See Lockwood (1998) for a formal statement and proof of this Proposition.

So, in the event that at least one project has a positive externality, there is a unique equilibrium with vote-trading, which coincides with the outcome of the voting game studied above. This proposition has a striking implication that if $n^+ > 0$, the outcome with vote-trading is *exactly the same* as with no coordination between legislators. Specifically, coordination does not allow legislators to incorporate the benefits of projects into the political decision-making process. So, Propositions 2–5 of the previous section, concerning the relative efficiency of (de)centralization, continue to hold.

7.4. *Universalism in Congress*

Our extension of the distributive politics model to allow for spillovers provides an alternative explanation for the empirical phenomenon of "universalism" in the U.S. Congress. This refers to the empirical regularity that packages of region-specific policies in the U.S., such as harbours, urban renewal programmes, military procurement, *etc*. funded by Congress provide benefits to more than a bare majority of states (Shepsle and Weingast (1979)). This is regarded as a puzzle because decision-making is by majority vote, not unanimity vote, so it might be expected that only "minimum winning coalitions" of states might have projects funded (Inman and Rubinfeld, 1997*b*).

The leading[39] existing explanation for universalism is that before the identity of the minimum winning coalition is determined, (*i.e.* behind a "veil of ignorance") legislators prefer universalism (all projects funded), rather than just a majority, and so legislators enter into an implicit agreement to provide projects universally (Weingast (1979), Shepsle and Weingast (1979), Niou and Ordeshook (1985)).

Our paper provides an alternative explanation for universalism. It is clear from Proposition 1 that when externalities are large and positive, n^+ may be close to or equal to n, so (almost) all regions will have their projects funded. So, in our setting, universalism arises not though implicit cooperation, but through the fact that legislative rules allow for (partial) internalization of externalities.

8. CONCLUSIONS

This paper has presented a model where the relative merits of centralization and decentralization, and the performance of various constitutional rules for choosing between the two, can be evaluated. One key feature of the paper is that in the centralized case, we present a fully explicit model of a national legislature, where legislative rules, rather than behaviour, are taken as primitive. An important finding is that the uniformity of provision is *endogenously* determined by the strength of the externalities. When externalities are large and positive, an outcome closer to universalistic provision, rather than just a bare majority of funded projects, will occur. Moreover, this characterization of the behaviour of the legislature is robust to the introduction of logrolling, and of different specifications of the legislative rules.

This model allows to investigate in detail both the relative efficiency of centralization and decentralization, and of the performance of various constitutional rules for choosing between them. To some extent, our analysis confirms Oates' insights that decentralization is the more efficient arrangement when externalities are small and/or regions are heterogenous. However, the conditions required for increased heterogeneity to imply increased efficiency of decentralization are strong, essentially because the cost of centralization is not policy uniformity, but inefficient

39. For an alternative explanation of universalism, see Groseclose and Snyder (1996).

choice of projects due to cost-sharing and lack of responsiveness of the legislative process to benefits.

One limitation of the analysis is that it only considers two regimes, one where decisions about local public goods for all regions are centralized, and the other where they are all decentralized. In practice, in many federal and unitary states, such as the U.K., some regions (*e.g.* Scotland) have more fiscal powers than others. In future work, I plan to use the tools of this paper to analyse this kind of partial decentralization.

APPENDIX

A.1. *An example with no Condorcet winner in $\mathcal{N}_\emptyset$ when A2 is violated*

Assume $n = 3$, $\lambda_i = \frac{1}{3}$, $c_i = 0$, $b_i = 3$, $i = 1, 2, 3$, and $e_{12} = -2{\cdot}25$, $e_{13} = 2$, $e_{21} = 2$, $e_{23} = -2{\cdot}25$, $e_{31} = -1{\cdot}5$, $e_{32} = -1$. Note that regions 2, 3 do not agree on whether the externality from 1 is positive or negative, (and neither do regions 1, 2 agree about the externality from 3), so A2 is certainly violated.

Define the non-empty alternatives in $\mathcal{N}$ as: $N = \{1, 2, 3\}$, $A = \{1, 2\}$, $B = \{1, 3\}$, $E = \{2, 3\}$, $F = \{1\}$, $G = \{2\}$, $H = \{3\}$. Then using the formula (3.7), it is easy to calculate that regions have the following rankings over $\mathcal{N}$:

$$1\text{: } B \succ_1 F \succ_1 N \succ_1 H \succ_1 A \succ_1 \emptyset \succ_1 E \succ_1 G,$$
$$2\text{: } A \succ_2 G \succ_2 N \succ_2 F \succ_2 E \succ_2 \emptyset \succ_2 B \succ_2 H,$$
$$3\text{: } H \succ_3 E \succ_3 B \succ_3 N \succ_3 \emptyset \succ_3 G \succ_3 F \succ_3 A.$$

Then the set of those alternatives that are not beaten by the status quo in majority vote is

$$\mathcal{N}_\emptyset = \{F \in \mathcal{N} \,|\, F \succ \emptyset\} = \{A, B, E, F, H, N\}.$$

Note from the regional rankings that $A \prec B$, $B \prec E$, $E \prec F$, $F \prec N$, $H \prec N$, and finally $N \prec B$, so that there is no CW in $\mathcal{N}_\emptyset$.

A.2. *Proofs of Lemmas and Propositions*

Proof of Lemma 1. (a) Consider first the voting subgame given agenda $(G_1, G_2, \ldots, G_k, \emptyset)$. Assume that W is on the agenda. As the agenda is an amendment agenda, the unique SPE outcome of the voting subgame can be characterized in terms of the *sophisticated equivalent agenda* (Banks (1985)). The sophisticated equivalent agenda of $(G_1, G_2, \ldots, G_k, \emptyset)$ is a $(G_1^*, G_2^*, \ldots, G_k^*, \emptyset)$ which satisfies:

1. $G_k^* = G_k$ if $G_k \succ \emptyset$, and $\emptyset$ otherwise,
2. $G_l^* = G_l$ if $G_l \succ G_m^*$, all $m > l$, and $G_l \succ \emptyset$, and $G_l^* = G_m^*$ otherwise, all $1 \le l < k$.

Note that under the assumptions made (n odd and A0), the voting subgame is a tournament. As the game is a tournament, and as weakly dominated voting strategies are ruled out, it is a well-known result that the unique SPE outcome of the voting subgame is G_1^* (Banks (1985, Theorem 2.2)).

Now as W is on the agenda, $W = G_l$, for some $1 \le l \le k$. Now, note that $W \succ G_m^*$, all $m > l$. For suppose not. Then $G_m^* \succ W$, some $m > l$. But by construction, $G_m^* \succ \emptyset$, so that $G_m^* \in N_\emptyset$. It follows that W cannot be the unique CW in $N_\emptyset$, contrary to assumption. This is a contradiction, so $W \succ G_m^*$, all $m > l$, after all. But then from 2 above, we see that $G_l^* = W$.

Next, note that if $G_l^* = W$, $G_{l-1}^* = W$ also. For suppose not: then $G_{l-1} \succ W$ and $G_{l-1} \succ \emptyset$, by 2 above, which is again a contradiction. Repeating this argument, we see eventually that $G_1^* = W$. So, we conclude that if W is on the agenda, it is always the unique SPE outcome of the voting subgame.

(b) Now consider the proposal stage. Suppose that $W \notin \mathcal{A}$ in political equilibrium. Then, the equilibrium outcome will be some other $F \in \mathcal{N}_\emptyset$ (which will generally depend on the agenda π). But as W is the unique CW in $\mathcal{N}_\emptyset$, there must be some $i \in N$ who prefers W to F (otherwise, all delegates would prefer F to W, contradicting the fact that W is a CW in $\mathcal{N}_\emptyset$). So, i prefers to deviate by including W in his proposed set of alternatives, $\mathcal{A}_i$, contradicting $W \notin \mathcal{A}$. ‖

Proof of Lemma 2. For any $F \subset N$, define $v_i(F) = \sum_{j \in F} \sigma_{ij}$. So, we can write the payoff to i if F is funded under centralization as

$$u_i^c(F) = \begin{cases} b_i - \lambda_i c_i + v_i(F) & \text{if } i \in F, \\ v_i(F) & \text{if } i \notin F. \end{cases} \tag{A.1}$$

Note that by construction of N^+, $v_i(N^+) > v_i(F)$, all $F \neq N^+$. Now let $L \subset N$ be an arbitrary set. We will show that $N^+ \succ L$. Then, using (A.1), and assumption A1, we see that following a switch from funding L to N^+, we have the following gains for all $i \in (N/L) \cup N^+ = S$

$$u_i^c(N^+) - u_i^c(L) = v_i(N^+) - v_i(L) > 0, \qquad i \in N/(L \cup N^+) \quad \text{or} \quad i \in L \cap N^+, \tag{A.2}$$
$$u_i^c(N^+) - u_i^c(L) = [b_i - \lambda_i c_i] + v_i(N^+) - v_i(L) > 0, \qquad i \in N^+/(L \cap N^+).$$

So, $u_i^c(N^+) > u_i^c(L)$ for all $i \in S$. Now as $n^+ \geq m$, $\#S = s \geq m$, so a strict majority prefer N^+ to L, *i.e.* $N^+ \succ L$. ‖

Proof of Lemma 3. We will show that $N^+ \succ L$ for any $L \subset N$, $L \neq N^+$. Define the set S exactly as in the proof of Lemma 2. If $s \geq m$, then the argument is as in the proof of Lemma 2. However, as $n^+ < m$, it is now possible that $s < m$.

Case I: $L \cap N^+ = \emptyset$. Here $S = N/L$, so $s = n - l$, so $s < m$ can occur iff $l > n - m = m - 1$, or equivalently if $l \geq m$. To show that $N^+ \succ L$ in this case, it is certainly sufficient to have that $k \geq l - (n - m)$ delegates $i \in L$ strictly prefer N^+ to L; for then, $s + k \geq n - l + l - (n - m) = m$ delegates overall strictly prefer N^+ to L. But by assumption A3, $k \geq l - (m - 1) = l - (n - m)$ delegates $i \in L$ strictly prefer N^+ to L.

Case II: $L \cap N^+ \neq \emptyset$. Here, $N/L \subset S$, so $s \geq n - l$, so again it is sufficient for $N^+ \succ L$ that $k \geq l - (n - m) = l - (m - 1)$ delegates $i \in L$ strictly prefer N^+ to L, and again this follows from A3. ‖

Proof of Lemma 4. We show that when $n^+ = 0$, M is a Condorcet winner in $\mathcal{N}_\emptyset = \{F \in \mathcal{N} \mid F \succ \emptyset\}$ but not in $\mathcal{N}$. First, if $L \succ \emptyset$, it must be the case that $\#L = l \geq m$. To see this, note that delegates $i \in N/L$ always prefer $\emptyset$ to L because following a switch from $\emptyset$ to L, regions $i \in N/L$ have a net gain of $\sum_{j \in L} \sigma_{ij} < 0$ from the switch. Now if $\#L < m$, delegates $i \in N/L$ are in the majority, implying $\emptyset \succ L$.

So, let $L \subseteq N$ be such that $\#L = l \geq m$. It is then sufficient to show that M is preferred to any L. Also, recall that regions are ranked in terms of increasing (negative) externality. But for $i \in M$:

$$u_i^c(M) - u_i^c(L) = \left(\sum\nolimits_{j \in M/\{i\}} \sigma_{ij} - \sum\nolimits_{j \in L/\{i\}} \sigma_{ij}\right), \qquad i \in M \cap L, \tag{A.3}$$

$$u_i^c(M) - u_i^c(L) = b_i - \lambda_i c_i + \left(\sum\nolimits_{j \in M/\{i\}} \sigma_{ij} - \sum\nolimits_{j \in L} \sigma_{ij}\right), \qquad i \in M \cap (N/L). \tag{A.4}$$

From the facts (i) that $\sigma_{ij} < 0$, and (ii) by construction, M comprises the regions with the smallest negative externalities, the bracketed terms on the RHSs of (A.3), (A.4), must be positive. Also, by A1, $b_i - \lambda_i c_i > 0$. So, $u_i^c(M) - u_i^c(L) > 0,\ i \in M$, so $M \succ L$. ‖

Proof of Proposition 2. (i) When $e_{ij} = 0$, from (5.1), we have

$$W^d - W^c = \sum\nolimits_{i \in N} [\max\{b_i - c_i, 0\} - x_i^M (b_i - c_i)] \geq 0.$$

As $b_i \neq c_i,\ i \in N$, the inequality is strict if $D \neq C = M$.

(ii) From (3.8), we can write

$$W^c = \sum\nolimits_{i \in C} (b_i - \lambda_i c_i) + \sum\nolimits_{i \in N} \sum\nolimits_{j \in C} \sigma_{ij}. \tag{A.5}$$

Also, from (3.4), we get, after simple rearrangement;

$$\begin{aligned} W^d &= \sum\nolimits_{i \in D} (b_i - c_i) + \sum\nolimits_{i \in N} \sum\nolimits_{j \in D} e_{ij} \\ &= \sum\nolimits_{i \in D} (b_i - \lambda_i c_i) + \sum\nolimits_{i \in D} \sum\nolimits_{j \in N/\{i\}} (-\lambda_j c_i) + \sum\nolimits_{i \in N} \sum\nolimits_{j \in D} e_{ij} \\ &= \sum\nolimits_{i \in D} (b_i - \lambda_i c_i) + \sum\nolimits_{i \in N/\{j\}} \sum\nolimits_{j \in D} (-\lambda_i c_j) + \sum\nolimits_{i \in N} \sum\nolimits_{j \in D} e_{ij} \\ &= \sum\nolimits_{i \in D} (b_i - \lambda_i c_i) + \sum\nolimits_{i \in N} \sum\nolimits_{j \in D} \sigma_{ij}. \end{aligned} \tag{A.6}$$

Now, assume $D \subseteq N^+ = C$. Then from (A.5), (A.6), we have:

$$W^c - W^d = \sum\nolimits_{i \in C/D} (b_i - \lambda_i c_i) + \sum\nolimits_{i \in N} \sum\nolimits_{j \in C/D} \sigma_{ij}. \tag{A.7}$$

Now, by A1, the first term is strictly positive if $D \neq C$. Also, by the construction of $N^+ = C$, $\sigma_{ij} > 0$ for all $i \in N$, $j \in C$, and $\sigma_{ii} = 0$. So, (A.7) is certainly strictly positive if $D \subset C$. ∥

Proof of Proposition 3. From (3.4), (3.7) we can write

$$W^d - W^c = \sum_{j \in D/C} v_i - \sum_{j \in C/D} v_i + \sum_{i \in N} \left(\sum_{j \in D} e_{ij} - \sum_{j \in C} e_{ij} \right). \tag{A.8}$$

Now, any symmetric MPS can be decomposed into a sequence of simple symmetric MPSs (Rothschild and Stiglitz (1970)), so it is sufficient to show that the result is true for a single simple symmetric MPS. First, recall that we have ordered the regions by increasing cost. Reorder them by increasing net benefit *i.e.*

$$v_1 \leq v_2 \cdots \leq v_n,$$

where $v_m = 0$ from assumption A6. With this ordering, a simple symmetric MPS of $\{v_k\}_{k \in N}$, $\{v'_k\}_{k \in N}$, is a transformation such that $v'_{m-i} = v_{m-i} - \delta$, $v'_{m+i} = v_{m+i} + \delta$, for some $1 \leq i \leq m-1$, and $v'_j = v_j$ all other j. But it is clear that this transformation leaves D unchanged (as no v_i changes sign), and (weakly) raises $\sum_{j \in D/C} v_i$, and (weakly) lowers $\sum_{j \in C/D} v_i$. The proof is completed by noting that if (i) $e_{ij} < 0$, or (ii) costs are left unchanged in the MPS, then net spillovers are left unchanged, and so from Proposition 1, C is left unchanged. So, from (A.8), $W^d - W^c$ cannot fall following the simple symmetric MPS. ∥

Proof of Proposition 4. (i) We first prove the first part of the Proposition. As $D = \{i \in N \mid b_i \geq c_i\}$, then for ε small enough, and recalling $\bar{b} \neq \bar{c}$ by assumption we see

$$D = \begin{cases} N & if\ \bar{b} > \bar{c}, \\ \emptyset & if\ \bar{b} < \bar{c}. \end{cases}$$

Now, by assumption, $d \neq n$ so we are in the case where $\bar{b} < \bar{c}$. So, for ε small enough, $D = \emptyset$ and so $u_i^d = 0,\ i \in N$. Also, by assumption $C = N^+ = N$. So,

$$u_i^c = b_i - \lambda_i c_i + \sum_{j \in N} \sigma_{ij}.$$

So, to show $u_i^c > u_i^d$, $i \in N$, we only need show that $u_i^c > 0$. But $b_i - \lambda_i c_i > 0$ by A1, and $\sigma_{ij} > 0$, all $i, j \in N,\ i \neq j$ as $N^+ = N$.

(i) We now prove the second part of the Proposition. If $e_{ij} = 0$, then $\sigma_{ij} = -\lambda_i c_j < 0$. In this case, from Proposition 1, $C = M$, so $i \in M/D$ only get a project with centralization. So, by A5, all $i \in M/D$ strictly prefer centralization. So, the only way in which decentralization could be Pareto-preferred is if $M/D = \emptyset$, *i.e.* if $M \subset D$. Assume that this is the case. But then, supposing that regions are indexed by increasing project cost, and $\lambda_m < 1/m$ by assumption, we have:

$$u_m^d = b_m - c_m < b_m - \frac{1}{m} \sum_{j=1}^m c_j < b_m - \lambda_m \sum_{j=1}^m c_j = u_m^c,$$

i.e. the agent with the median cost strictly prefers centralization. So, decentralization can never be Pareto-preferred. ∥

Proof of Proposition 5. (i) When $e_{ij} = 0$, clearly all i not in $C = M$ strictly prefer decentralization, as $\max\{b_i - c_i, 0\} > -\frac{1}{n} \sum_{j \in C} c_j$. As $\#C = m$, and n is odd, it suffices to find only one $i \in C$ who strictly prefers decentralization also, and we are done (for then a strict majority will prefer decentralization). Now note that given A4, and $\sigma_{ij} = -c_j/n$, regions are ordered by increasing cost. So, C comprises the m lowest-cost regions, so by definition, $1 \in C$. So, combining this fact with $c_1 < \frac{1}{n} \sum_{j=1}^m c_j$, we see

$$u_1^d \geq b_1 - c_1 > u_1^c = b_i - \frac{1}{n} \sum_{j=1}^m c_j.$$

So, 1 prefers decentralization, as required.
(ii) If $N^+ = N$, then

$$u_i^c = b_i - \bar{c} + \sum_{j \in N} e_{ij},\ u_i^d = \max\{b_i - c_i, 0\} + \sum_{j \in D} e_{ij}.$$

By assumption, $d \neq n \neq m$. Assume first that $n > d > m$. Now, as $|c_i - \bar{c}| < \varepsilon$, and $e_{ij} > 0$, if we choose ε small enough, then

$$u_i^c > b_i - c_i + \sum_{j \in N} e_{ij} - \varepsilon > b_i - c_i + \sum_{j \in D} e_{ij} = u_i^d,$$

for all $i \in D$. So, a majority strictly prefer C to D if costs are homogeneous enough.

Now suppose that $d < m$. Then for all $i \in D$, we can show that $u_i^c > u_i^d$ as before. Also, by definition of β_m, we can find $m - d$ members of N/D with $b_i \geq \beta_m$. Let the set of such members be S. Then for all $i \in S$, for ε small enough:

$$u_i^c > b_i - \bar{c} + \sum_{j \in N} e_{ij} - \varepsilon \geq \beta_m - \bar{c} + \sum_{j \in N/D} e_{ij} + \sum_{j \in D} e_{ij} - \varepsilon.$$

But by assumption, $\beta_m - \bar{c} + \sum_{j \in N/D} e_{ij} > 0$. So, for ε small enough, $u_i^c > u_i^d = \sum_{j \in D} e_{ij}$, $i \in S$. But then overall, a strict majority of regions prefer centralization. ‖

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