On the Determinants of Cooperative Public Good Provision

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Aamee tuma ke bhalo aashi

To Iris

Acknowledgements

Biff and George from 'Back to the Future' meet again at a game theory class in college. At the end of the term, the class is due to take an exam with grades marked decreasing from 6 to -6. George, the nerd, attends readings on a regular basis whereas Biff, the bully, can choose to either *study* hard or *skip* readings. If Biff decides to study hard, he attends readings and prepares for the exam all by himself. On the other hand, he can spend his days at the beach and ask for George's help some two weeks before the actual exam. George can then choose to either *even* things out with Biff or try to *complete* his own preparations. Strategy choices are italicized.
In case Biff chooses to study on his own, George is allowed undisturbed preparation, resulting in grades of -2 and 6, respectively. In case George chooses to even things out, he spends lots of time eliminating Biff's deficiencies and fails to accomplish his own preparations. Hence, Biff obtains a 0 whereas George scores a mere 4. In the event of George trying to complete his own preparations, he is bullied by Biff's gang (they steal George's glasses, slap his head, etc.). This distraction, eventually, results in the giving of grades -4 and 2 for Biff and George.

Find the pure strategy Nash equilibria. Check them for subgame perfection and compare your results.

A great many heartfelt thanks go to my parents, and to Asif Masum, Tanja Burckardt, our former fellow-worker Sascha Ebigt, as well as our diligent secretary Isabella Grim, conference/seminar participants in Ankara, Bonn, Brühl, Erfurt, and Rome, the DFG, Cologne university's considerate administration, the VFS for valuable financial support, and to my club, Schalke 04. Last but not least, I would like to dedicate some words to the man I was entitled to work for over the last four years of my academic development, my PhD supervisor, Prof. Wolfgang Kitterer. As a matter of fact, you did at no time hesitate to support me, show interest in my thesis, offer help on many occasions, and exert effort to supervise my work. Looking back on the last 39 months, I thank you for all the encouragement and help you gave to me. I have learnt many things and missed nothing. Special thanks go to my mentors, Christoph Lülfesmann and Karl Schlag.

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List of Important Symbols

α	measure for risk-aversion
β	preference for a public good
δ	discounting parameter
π	stage game payoffs
Π	repeated game payoffs
σ	degree of interregional preference heterogeneity
τ	lump-sum tax
ϕ	degree of interregional public good spillovers
ω	income
$*$	index for cooperation
a	index for agenda power
C	index for centralization
d	index for defection
D	index for decentralization
e	index for stage game Nash-equilibria
g	local public good
G	pure public good
h	history of a repeated game
n	number of regions
x	private good

For the sake of clarity, the above list is not exhaustive. The notation of less important symbols is relegated to the main part of the text.

1. Introduction

1.1 Motivation

What determines the optimal degree of fiscal decentralization? An intense discussion concerning the current developments in Europe, Canada, and the Russian federation recalls that this question is of significant interest, both from an academic and non-academic point of view.

From an economic perspective, a viable guideline for assigning fiscal prerogatives is due to reflect a trade-off between the various layers' respective pros and cons with regard to the exercise of policies. In this line, decentralized regimes are acknowledged to implement policies in a way that accounts for the well-being of local residents, thus tending to neglect externalities on other localities. On the other hand, an abuse of political power at the federal layer may bring about a distribution of policy benefits that is excessively biased in favor of politically powerful regions. Intuitively, neither a centralized nor decentralized regime shows great promise for meeting the requirements of universally efficient policy-making. Hence, the normative case for policy assignment is determined by both institutional aspects as well as by characteristics of the policies to be assigned.

A body of fiscal federalism literature has, so far, analyzed the problem of assigning public good policy prerogatives within a federal hierarchy, putting forth some well-established answers to our initial question. The existing literature has, though, focussed on deriving policy guidelines in static frameworks. In such a framework, neither regime is likely to yield efficient policy outcomes, as, following a one-shot perspective of methodological individualism, the pursuit of short-run self-interest emerges as the dominant prediction concerning political behavior. Yet, policy implementation in the European Council can, for example, rather be characterized by a 'norm of voluntary unanimity', i.e. proposals requiring a mere qualified majority of votes are usually agreed on unanimously. In fact, these proposals are voted against by a mere 1.8 % average of Council votes.[1] This number challenges the standard theoretical prediction that policies are implemented in a way to serve the preferences of the bare majority of votes required for adopting a policy proposal.[2] Similarly, the free-riding problem associated with voluntary decentral public good provision may be overcome in spite of the downbeat theoretical prediction emerging for the prisoner's dilemma structure.[3] The question emerging from these observation is straightforward. What institutional and non-institutional facets of policy-making may prevent political actors from implementing inefficient policies?

The challenge for this dissertation is to explain apparently cooperative patterns of political behavior on a theoretical basis. Due to the one-shot perspective of policy-making, establishing the basic setup for the existing fiscal federalism literature, the latter finds it hard to do just that. Building on the prediction that both centralized and decentralized political regimes entail inefficient policy outcomes, static guidelines assign policies to the layer that minimizes the respective inefficiencies. The, beyond dispute, most popular guideline states that policies lacking (entailing) significant spillovers on other localities should be decentralized (centralized). On behalf of similar recommendations addressing other policy characteristics, this guideline is based on exactly such a comparison of inefficiencies. These guidelines fail, though, to capture dynamic aspects of policy-making such as forward-looking behavior, both at a federal and sub-federal layer. Our approach rather builds on the conviction that efficiency-sustaining coop-

[1] This number is based on 398 European Council decisions on policies requiring qualified majority (December 2000 - December 2003). We summed up the weighted averages of *nays* over all decisions and related this number to the total of decisions. The *Summary of Council Acts* is released on a monthly basis at http://register.consilium.eu.int/isoregister/frames/introacfsEN.htm.

[2] See, e.g. Riker and Ordeshook (1973).

[3] See, e.g. Axelrod (1984) for numerous empirical examples.

eration among political decision makers may overcome short-run inefficiencies in the course of repeated political interaction. We, therefore, argue that a viable guideline for policy assignment is supposed to capture a regime's ability to cope with negative short-run interests.

Motivating our dynamic approach of modeling fiscal federalism frameworks, a look at actual federal legislatures tells us that there is rather repeated political interaction among representatives. Table 1.1 depicts the number of European Summits attended by average heads of state and government from the respective member states of the European Union.[4] Accordingly, an average Danish *statsminister* politically interacts with representatives from other European member states on at least 24 occasions before finally leaving office.

	AT	BE	DE	DK	ES	FI	FR	GR	IE	IT	LU	NL	PT	SE	UK
S	38	96	96	96	63	38	96	78	96	96	96	96	63	38	96
H	3	6	3	4	2	4	3	7	7	15	4	5	2	2	5
S/H	12.7	16.0	32.0	24.0	31.5	9.5	32.0	11.1	13.7	6.4	24.0	19.2	31.5	19.0	19.2

S: # of European Summits attended by heads of state and government from the respective nation

H: # of different heads of state and government since nation joined the European Union

Table 1.1: European Summits

Similar numbers for the United States of America reveal that the average incumbency of representatives in the present US Congress amounts to 4.6 terms.[5] These numbers certainly motivate a 'more-than-one-shot' perspective of policy-making. As the latter has been neglected by the existing fiscal federalism literature, one might ask what happens to the guidelines for policy assignment if we allow for dynamic interaction. Of course, this kind of neglect is innocuous in case the emerging guidelines are invariant with respect to the temporal framework. Yet, our repeated game analysis shows that

[4]See European Commission (2003). Table 1.1 comprises a total of 96 summits, ranging from the first European Summit (March 10-11, 1975, Dublin) to the 2003 summit in Brussels (October 16-17).

[5]See Amer, M. (2004), p. 4.

the transition from a static to a dynamic perspective of policy-making may significantly modify the prediction concerning federal and decentral policy equilibria and, more importantly, reverse some well-established guidelines for policy assignment.

1.2 Aims and Structure of the Dissertation

This dissertation aims at identifying determinants of cooperative public good provision in dynamic frameworks. We develop *political economy* based models of fiscal federalism and establish normative benchmarks as well as equilibrium predictions for both policy-making under a centralized and decentralized regime. In the tradition of Oates' (1972) seminal fiscal federalism treatise, our models analyze the regimes' pros and cons for various facets of institutional policy-making. Yet, placing emphasis on the dynamic structures of policy-making, we introduce guidelines for policy assignment to layers of a federal system in repeated game settings. The bottom line for this thesis is to analyze the impact of factors like public good spillovers, regional preference heterogeneity, and the number of federal member states on the regime-specific ability to yield efficient public good policies. Let us illustrate the thread of this dissertation.

The next chapter starts with a representation of the genuine fiscal federalism framework à la Oates (1972). Section 2.2 illustrates the basic normative guidelines for policy assignment, for instance the celebrated *decentralization theorem*, in a formal framework. The literature survey in section 2.3 classifies and highlights some contributions that can be related to Oates' work.

Chapter 3 introduces our political economy framework and analyzes the optimal assignment of spillover policies in an economy with 2 regions. Our static perspective (section 3.3) confirms the above-mentioned standard fiscal federalism result, in particular the positive correlation between spillovers and the optimal degree of centralization. Allowing for dynamic interaction, this very guideline for policy assignment is, though, reversed in section 3.4 as efficient public good policies are then easier to sustain under a decentralized (centralized) regime in case spillovers are large (small).

Chapter 4 applies the framework of chapter 3 to a setting with interregional preference heterogeneity. As a major result, both regimes fail to yield efficiency-sustaining cooperation in the repeated game setting if the regional preferences for public goods differ substantially.

Chapter 5 extends the basic framework to a n-region economy, thus enabling us to analyze the impact of federal enlargements on the prospects of attaining efficiency. Varying the degree of spillovers as well as the type of public good funding, we apply the extended basic framework to different problems of public good allocation. In each case, enlargements induce two countervailing effects on the ability to maintain efficiency in a federal legislature. Yet, cooperation necessarily breaks down in large legislatures whereas, at the same time, efficiency can be sustained at the decentral layer.

At last, chapter 6 endogenizes the very impact of repeated interaction on cooperation by allowing for (political) decision makers that face strategy-contingent re-election probabilities. Concluding our determinants of efficient public good provision, we show that cooperation can, quite generally, be attained if politicians face a high likeliness of joint future interaction. Chapter 7 summarizes our results.

2. Oates and Fiscal Federalism

2.1 Fiscal Federalism According to Oates

The initial point for Oates' analysis is characterized by the opinion that "*we need to understand which functions and instruments are best centralized and which are best placed in the sphere of decentralized levels of government. This is the subject matter of fiscal federalism.*"[6] In his seminal work, Oates (1972) places emphasis on the optimal assignment of public good policies. His respective guidelines, the decentralization theorem in the first place, have undisputedly prepared the ground for a well-founded understanding of federal structures. In particular, the joint normative analysis of (de)centralization's pros and cons sheds light on the problem why the administration of public good policies should be centralized at all.

As argued by Tiebout (1956), decentral structures may already yield an efficient allocation of public goods. However, for a decentralized regime to yield efficient policies, Tiebout's model requires that (i) individuals must be costlessly mobile among jurisdictions and (ii) local public goods do not induce spillovers on other jurisdictions.[7] Whereas the first assumption may have its virtues for an intranational perspective of fiscal federalism, it appears inappropriate for an international context. In this line, Alesina, Angeloni and Schuknecht (2001) challenge the explanatory power of the Tiebout-based branch of the fiscal federalism literature. In their words, the Tiebout

[6] Oates (1999), p. 1120.

[7] Furthermore, public goods must be provided at minimum average costs, a sufficiently differentiated supply of political jurisdictions is due to be costlessly available, and individuals are supposed to obtain full information about the implemented policies. See Crémer, Estache and Seabright (1996), pp. 41, for an extensive critique of Tiebout's approach.

approach "*heavily emphasizes individual mobility across jurisdictions, a phenomenon, which applies only to a limited extent to the European Union.*"[8] Assumption (ii) furthermore reduces the possible validity of the Tiebout hypothesis to pure local public goods.

In support of the Tiebout approach, Coase (1960) suggests that decentral regimes may overcome externality problems associated with interjurisdictional public good spillovers. His argument is essentially based on the fact that externalities leave an additional overall surplus to be allocated. Whenever mutual free-riding induces jurisdictions to underprovide public goods, these regions might benefit from extending the level of provision. An efficient decentral implementation of public good policies can be achieved if a contractual agreement concerning the allocation of the respective costs and benefits can be both negotiated and, furthermore, enforced by a third party at no costs. Yet, the latter requirement has led to a rejection of the Coase solution in a context of international externalities. This rejection is based on the fact that the validity of international contracts (e.g. climate protection, disarmament) suffers from the actual absence of operative supranational enforcement authorities.[9]

Oates' (1972) framework builds on the conviction that a centralized administration of public good policies aims to internalize interjurisdictional externalities whereas a decentralized implementation of spillover policies entails insurmountable inefficiencies. Restricting the analysis to immobile residents, he places less emphasis on the effects of interregional migration. Yet, his analysis allows for interregional public good spillovers. Assigning policy prerogatives to a central layer may, therefore, yield benefits in terms of policy coordination. On the other hand, Oates' analysis interprets "*a 'centralized solution' to the problem of resource allocation in the public sector as one that empha-*

[8] Alesina, Angeloni and Schuknecht (2001), p. 1. Giving support to this critique, cross-border mobility of European Union residents is limited to 0.1 % a year (European Commission (2000), p. 18). Tassinopoulos and Werner (1999), cha. 4, discuss the determinants of the observable immobility between member states of the European Union. In essence, the authors find that residents face substantial mobility costs.

[9] See Inman and Rubinfeld (1998), pp. 7, for a detailed critique of Coase's approach.

sizes standardized levels of service across all jurisdictions".[10] Hence, centralization of policies is a rather mixed blessing as the center internalizes public good spillovers but fails to account for interjurisdictional heterogeneity.

Summarizing Oates' ideas, a decentralized regime is considered as 'closer to the people' whereas central governance incorporates externalities. As the below formal representation of Oates' model exhibits, the optimal degree of decentralization is determined by a trade-off between these forces.

2.2 A Formal Representation of Oates' Insights

Besley and Coate (1999) present a formal treatment of the fiscal federalism framework à la Oates.[11] The authors derive the genuine Oates (1972) results and go on to compare the latter to results from a political economy setting. Whereas we shall discuss the political economy results in section 2.3, the present section recaptures the Besley and Coate (1999) presentation of Oates' model.

2.2.1 Economic Environment

The economy consists of two geographically distinct regions $i = 1, 2$. Immobile regional populations are normalized to 1, respectively. Individuals hold preferences over local public goods g and private goods x. For an individual in region i, these preferences are represented by utility

$$U_i\left(x_i, g_i, g_{-i}\right) = \left(1-\beta_i\right)\ln x_i + \beta_i\left[\left(1-\phi\right)\ln g_i + \phi \ln g_{-i}\right] \tag{2.1}$$

where $\phi \in \left[0, \frac{1}{2}\right]$ and $0 < \beta_i < 1$.[12] The price for local public goods is set to p whereas

[10] Oates (1977), p. 4.

[11] We adapt their original notation in order to correspond to our notation used in subsequent chapters. Unfortunately, the Besley and Coate (1999) article does not feature any kind of page numbering. Where appropriate, the quotation, therefore, refers to overall contents.

[12] Observe that (2.1) represents Cobb-Douglas utility with 3 goods. In the original presentation

the price for private goods is normalized to 1. Furthermore, individuals in both regions are endowed with exogenous income ω.

According to (2.1), public goods may induce interregional spillovers. The degree of spillovers is measured by the parameter ϕ. Restricting the analysis to $\phi \leq \frac{1}{2}$ ensures that individuals obtain at least as much a benefit from public good provision in their home region as from provision abroad. For $\phi = 0$, utility in region i does not depend on public goods that are provided in the other region. In this case, g represents local public goods. The polar case of $\phi = \frac{1}{2}$ implies that utility in region i is utmost affected by provision in the other region. Due to the strong complementarity between regional public goods, individuals in one region then prefer equal levels of public goods in their home region and abroad. Yet, these preferred levels differ among regions whenever $\beta_1 \neq \beta_2$.[13]

Capturing the standard framework of Oates' model, Besley and Coate go on to analyze equilibrium policies under both a decentralized and centralized regime. As a benchmark for policy evaluation, the authors employ a utilitarian welfare function

$$W^{+} = \sum_{i=1}^{2} \left\{ (1-\beta_i) \ln x_i + \beta_i \left[(1-\phi) \ln g_i + \phi \ln g_{-i} \right] \right\}. \tag{2.2}$$

The next section presents the process of policy implementation under a centralized regime.

of the model, there is intraregional preference heterogeneity as well. The latter is captured by a cumulative distribution function $F_i(\beta)$ on support $\left[0, \bar{\beta}\right]$, where $\bar{\beta} < 1$. We shall, though, restrict the analysis to the case of interregional heterogeneity.

[13] Note that the case of $\phi = \frac{1}{2}$ does *not* imply a pure public good setting. In a pure public good setting, regional utility rather depends on the aggregate public good quantity available in the entire economy but not on the interregional distribution (see e.g. Samuelson (1954)). The utility in (2.1) rather varies in this very distribution.

2.2.2 Centralized Public Good Provision

Under a centralized regime, a benevolent central planner chooses public good quantities for both regions. To this end, the planner levies lump-sum taxes

$$\tau_i^C = \frac{p}{2}(g_1 + g_2), \tag{2.3}$$

i.e. public good provision is financed via equal regional tax burdens. Following the genuine Oates (1972) framework, Besley and Coate assume that the planner is restricted to uniform provision levels $g_1^C = g_2^C = g^C$. Accordingly, the regional budget constraints read as

$$\omega = x_i + pg. \tag{2.4}$$

The benevolent central planner chooses regional public good policies g^C in a way that maximizes the overall welfare in (2.2) subject to both the regional budget constraints and the uniformity constraint. Hence, the level of regional public good provision under a centralized regime is characterized by

$$g^C = \arg\max_{g \geq 0} \{(2 - \beta_1 - \beta_2) \ln(\omega - pg) + (\beta_1 + \beta_2) \ln g\}. \tag{2.5}$$

Whereas Besley and Coate determine the allocation in (2.5) algebraically, we shall rather make use of some standard results for Cobb-Douglas utility.[14] Accordingly, the solution of (2.5) comprises the central planner spending fractions $\frac{2-\beta_1-\beta_2}{2}$ and $\frac{\beta_1+\beta_2}{2}$ of income on regional private and public goods consumption, respectively. Hence, the centralized administration of public good policies entails quantities

[14] See, e.g. Varian (1992), p. 111.

$$\left\{g^C, x^C\right\} = \left\{\frac{2-\beta_1-\beta_2}{2}\omega, \frac{\beta_1+\beta_2}{2}\frac{\omega}{p}\right\} \tag{2.6}$$

for both regions. Due to the uniformity assumption, the public good quantities in (2.6) merely account for average regional public good preferences instead of reflecting the region-specific tastes. Intuitively, there are welfare gains associated with a differentiated public good provision. This fact is discussed in more detail in section 2.2.4.

Inserting (2.6) into (2.2), the welfare under a centralized regime reads as

$$W^C = (2-\beta_1-\beta_2)\ln\frac{(2-\beta_1-\beta_2)\,\omega}{2} + (\beta_1+\beta_2)\ln\frac{(\beta_1+\beta_2)\,\omega}{2p}. \tag{2.7}$$

Note that W^C does not depend on the degree of spillovers. Yet, this result is a mere artefact of the utility in (2.1). Generally speaking, the Oates model does not put any normative emphasis on how spillovers or preference heterogeneity affect a *single* regime. In fact, the relevant point is how a specific regime performs relative to the other regime. The next section shall, therefore, derive the equilibrium welfare for the decentralized regime.

2.2.3 Decentralized Public Good Provision

Under a decentralized regime, regional planners maximize the welfare in their respective localities. Simultaneously, these planners choose regional public good quantities in the course of a non-cooperative contribution game. Each region provides a quantity g_i that is financed via regional head taxes

$$\tau_i^D = pg_i. \tag{2.8}$$

Taking the other region's provision of public goods g_{-i} as given, the planner in region

i divides regional resources among public goods g_i and private goods x_i. The *Nash-equilibrium* quantities $\{g_1^D, g_2^D\}$ for this game satisfy

$$g_i^D = \arg\max_{g_i \geq 0} \left\{(1-\beta_i)\ln(\omega - pg_i) + \beta_i\left[(1-\phi)\ln g_i + \phi \ln g_{-i}^D\right]\right\}, \qquad (2.9)$$

i.e. expecting the other region's optimal contribution, the planner in region i provides a quantity g_i in a way to maximize her region's welfare. Figure 2.1 illustrates the corresponding reaction curves for region 1 (solid line) and region 2 (dashed line) in a symmetric scenario with identical regional preferences.

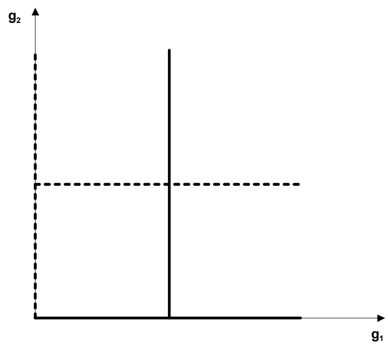


Figure 2.1: Reaction curves in the decentralized setting (source: own illustration)

In case region $-i$ provides no public goods, the planner from region i is indifferent between all admissible public good levels. This artefact of Cobb-Douglas utility yields a second (zero-provision) Nash-equilibrium that should be eliminated by restricting the analysis to strictly positive quantities. More importantly, figure 2.1 illustrates that the optimal quantity provided by region i neither decreases nor increases in the quantity provided by region $-i$. Hence, regional public good quantities are neither strategic substitutes nor strategic complements. This implies that the equilibrium regional provision is the same whatever quantity the other region provides.[15] We, therefore, rather

[15] Due to the separability of utility, the β-continuum of regional reaction curves is characterized by

interpret the problem in (2.9) as a standard household theory consumption decision. Accordingly, a regional planner maximizes her region's Cobb-Douglas utility subject to the regional budget constraint. Making use of the well-known results for this type of utility, the regional planners spend fractions $\frac{1-\beta_i}{1-\beta_i\phi}$ and $\frac{\beta_i(1-\phi)}{1-\beta_i\phi}$ of income on private and public good consumption in their respective regions. Hence, the decentralized regime entails quantities

$$\left\{x_i^D, g_i^D\right\} = \left\{\frac{1-\beta_i}{1-\beta_i\phi}\omega, \frac{\beta_i\left(1-\phi\right)}{1-\beta_i\phi}\frac{\omega}{p}\right\} \qquad i = 1, 2. \tag{2.10}$$

Contrasting the centralized setting, regional policies can now be tailored to cater region-specific preferences. On the other hand, the voluntary contribution game induces a free-rider problem, i.e. the average public good quantity is lower under the decentralized regime.[16] Deciding on public good provision in her own region, a regional planner ignores the positive spillovers on the other region. In the presence of spillovers, the decentralized equilibrium entails an inefficiently low level of provision because decision-makers do not account for the mutually positive willingness to pay for the respective public goods.

Substituting (2.10) into (2.2), the welfare under a decentralized regime reads as

$$W^D = \sum_{i=1}^{2}\left\{\left(1-\beta_i\right)\ln\frac{\left(1-\beta_i\right)\omega}{1-\beta_i\phi} + \beta_i\left[\left(1-\phi\right)\ln\frac{\beta_i\left(1-\phi\right)\omega}{\left(1-\beta_i\phi\right)p} + \phi\ln\frac{\beta_{-i}\left(1-\phi\right)\omega}{\left(1-\beta_{-i}\phi\right)p}\right]\right\}. \tag{2.11}$$

It can be shown that (2.11) decreases in spillovers. Once more, there is no immediate normative implication from this isolated fact. The relevant question is how both

parallel translations of the $\mathbb{R}^2_+$-part.

[16] Observe that both regimes yield the same average quantities for $\phi = 0$. Furthermore, both g_1^D and g_2^D decrease in ϕ, whilst g^C does not depend on spillovers.

regimes perform compared to one another.

2.2.4 Regime Ranking

Recall that both regimes are likely to entail inefficiencies for reasons of free-riding (decentralized regime) and policy uniformity (centralized regime), respectively. The regime ranking is, therefore, supposed to depend on the respective magnitude of the distortion. Besley and Coate (1999) compare the regime-specific welfare terms in (2.7) and (2.11). They summarize the results of the standard Oates model in the following proposition.[17]

Proposition 1 *If $\beta_1 \neq \beta_2$, (i) either a decentralized regime is welfare-superior for all values of ϕ, (ii) or there exists a critical level $\hat{\phi} > 0$ in a way that a centralized regime is welfare-superior iff $\phi > \hat{\phi}$. (iii) If $\beta_1 = \beta_2$ and $\hat{\phi} > 0$, the centralized regime is welfare-superior to the decentralized regime. If $\phi = 0$, the two regimes generate the same level of welfare.*

We shall abstract from the formal proof and rather illustrate these results graphically.

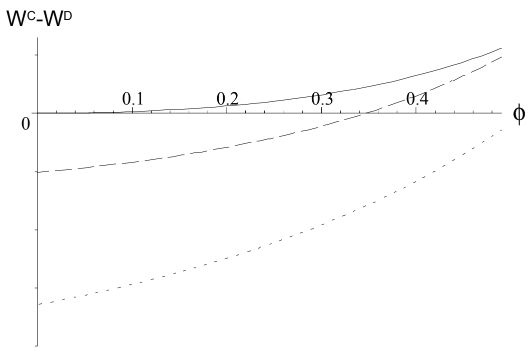


Figure 2.2: Welfare gap in the Oates model (source: own calculations)

[17]Besley and Coate (1999), first proposition, section *Oates' Analysis*.

Figure 2.2 depicts the welfare gap, i.e. the difference between (2.7) and (2.11), as a function of the spillover ϕ. Accordingly, the centralized (decentralized) regime is welfare-superior for positive (negative) values of the gap. We assign values $\omega = 10$, $p = 1$, and $\beta_1 = 0.5$ and depict the welfare gap for $\beta_2 = 0.5$ (solid line), $\beta_2 = 0.8$ (dashed line), and $\beta_2 = 0.97$ (dotted line). Observe that the welfare gap increases monotonically in spillovers for all three configurations. Analytically, this is due to the fact that W^C does not depend on spillovers whereas W^D decreases in ϕ.

The solid line represents the case of identical interregional preferences. Illustrating part (iii) of proposition 1, the centralized regime then dominates the welfare-ranking for positive spillovers whilst both regimes perform equally well in the absence of spillovers. The intuition for this result is straightforward. For identical regional preferences, there is no need to differentiate public good quantities as both regions prefer the same public good quantity. Hence, uniform public good provision entails no inefficiencies at all whereas the externality problem already arises for minor spillovers under the decentralized regime. Centralization, therefore, welfare-dominates decentralization.

The vice versa result is illustrated by the fact that the decentralized regime welfare dominates centralization for pure local public goods ($\phi = 0$) in both heterogeneity configurations whilst both regimes perform equally well for identical regional preferences. Whereas the benevolent central entity now encounters costs in terms of neglected heterogeneity of regional preferences, there is no externality problem. Owing to the local government's superior ability to tailor taste-specific policies, heterogeneous regional tastes, therefore, reject centralization from a normative point of view. This finding is the very same as in Oates' celebrated decentralization theorem. The latter states that "*in the absence of cost-savings from the centralized provision of a [local public] good and of interjurisdictional externalities, the level of welfare will always be at least as high (and typically higher) if Pareto-efficient levels of consumption of the good are provided in each jurisdiction than if any single, uniform level of consumption is maintained* *across all jurisdictions*"[18]

The dotted line in figure 2.2 illustrates part (i) of proposition 1, demonstrating that the decentralized regime may even welfare dominate centralization for any degree of spillovers in a setting with high preference heterogeneity.

Finally, the dashed line represents the case of medium preference heterogeneity. Illustrating part (ii) of proposition 1, the decentralized (centralized) regime then yields a higher welfare for small (large) spillovers. Furthermore, there exists a critical spillover level in a way that the decentralized (centralized) regime is welfare superior for spillovers smaller (greater) than this threshold.

Summarizing Oates' findings, as illustrated by Besley and Coate's (1999) presentation, spillovers and/or homogeneity among regional preferences give rise to a centralized administration of public goods whereas decentralization is preferred in vice versa situations.

2.3 Related Literature

Inspired by Oates' (1972) seminal analysis, a great many contributions to the literature of fiscal federalism have analyzed the problem of assigning policy prerogatives to layers of a federal system. Generally speaking, this subsequent literature acknowledges the existence of regime-specific benefits. Accordingly, guidelines for optimal policy assignment reflect a trade-off between the regimes' comparative advantages. Yet, the recent literature explicitly challenges the essentials of Oates' conceptual framework for the latter tends to neglect political economy considerations.

[18] Oates (1972), p. 54. See p. 35 of that source for an alternative formulation of the decentralization theorem.

2.3.1 An Oates Critique

Indeed, the case for decentralization is generally somewhat arguable in Oates' framework as, relaxing the assumption of policy uniformity, benevolent central governance eradicates the case for decentralization. Due to the mere ability of policy replication, the benevolent center can then never do worse than *any* decentralized regime. And why would a benevolent entity, intrinsically striving for *Pareto-improvement*, ever implement uniform policies if there are gains associated with differentiation? Obviously, the implementation of uniform policies is not in the interest of the parties involved.

Lockwood (2002) summarizes the critique addressing benevolence-based frameworks by arguing that "*the challenge for these papers is to explain why decentralization might ever be welfare-superior to centralization.*"[19] Following this line of critique and taking methodological individualism seriously, we think that efficiency-seeking central planning should rather serve as a benchmark for policy evaluation than as a prediction of actual institutional behavior. Furthermore, the case for uniform centralized public good provision is rather unlikely to emerge in a political economy setting with self-interested politicians.[20]

Albeit its potential shortcomings, Oates' (1972) treatise has had a tremendous impact on the literature of fiscal federalism. Our non-exhaustive literature survey starts with a review of papers that are conceptually identical or similar to Oates' framework. We shall reduce the degree of similarity as we progress in the literature. A selection of relevant political economy based contributions is presented in the last part of the literature survey. These models differ sharply from the genuine Oates framework and actually prepare the ground for our own models.

[19] Lockwood (2002), p. 315, footnote 6.

[20] This latter point is discussed in more detail below.

2.3.2 Benevolent Planners and Exogenously Uniform Policies

Establishing the survey, Alesina and Wacziarg (1999), cha. 4, present a standard Oates framework. In their model, regional public goods and regional capital endowments determine the level of regional production. Yet, localities may be endowed with heterogenous capital stocks and furthermore benefit from public good provision in other regions. Following Oates' (1972) framework, a benevolent central government accounts for public good spillovers but is restricted to uniform regional expenditure levels for the respective local public goods. On the other hand, decentralized provision entails free-riding and, therefore, an inefficiently low level of public goods.

It comes to no surprise that the major results are essentially the same as in Oates' model. In particular, Alesina and Wacziarg (1999), pp. 21-22, find that the regional level of consumption is always higher under a centralized regime in case of identical regional capital stocks. Furthermore, if there is heterogeneity among regional capital endowments, there exists a critical degree of spillovers in a way that decentralization (centralization) yields higher levels of regional consumption for spillovers smaller (larger) than this critical level. Finally, the critical level of spillovers decreases in the ratio of capital stocks, i.e. more heterogeneity requires a higher degree of spillovers to make centralization worthwhile.

Whereas Alesina and Wacziarg (1999) derive Oates' results in a clear-cut formal fashion, their framework can be criticized for applying the same benevolent central entity and exogenously uniform policies.

2.3.3 Benevolent Planners

The assumption of exogenous policy uniformity is relaxed in those fiscal federalism models dealing with problems of asymmetric information (e.g. Caillaud, Jullien and Picard (1996), Klibanoff and Poitevin (1999), Gilbert and Picard (1995)). Yet, following the standard *principal-agent* literature, these models assume that the center pursues efficiency aims. In Caillaud, Jullien and Picard (1996), regional governments hold better information about relevant characteristics and actions of regional firms than the benevolent central government. The respective information is relevant for an efficient design of incentive contracts concerning region-specific production. Regional production induces interregional externalities that are ignored by regional governments whereas the central government aims to internalize the respective spillovers.

An optimal assignment of responsibilities always includes activity by regional governments as the latter are more efficient in extracting relevant information from regional firms. The case for central government activity merely arises for substantial spillovers but vanishes entirely for small spillovers.
This guideline for policy assignment is the very same as in Oates (1972). At first glance, it comes to a surprise that such a guideline emerges in an asymmetric information framework. The so called *revelation principle*, i.e. the standard contract theory result for principal-agent models, can be interpreted in a way that it is always the highest layer that should be involved in extracting relevant information.[21] Indeed, the case for decentralization in Caillaud, Jullien and Picard (1996) is driven by the fact that communication in terms of inter-governmental exchange of information between the central entity and regional governments is ruled out by assumption. If this was not the case, the central government should be able to employ an adequate contract to extract any additional information from the regional governments.

Hence, the Lockwood (2002) critique, as stated above, particularly applies to standard asymmetric information frameworks. Whenever central governments act like efficiency-seeking principals, any coexistence of federal layers with respect to the execution of tasks appears to be dispensable.

[21] Roughly speaking, the revelation principle states that no other design of contracts can ever do better than a special type of contract designed by a profit-maximizing principal. Applied to a fiscal federalism framework, this principle gives rise to an assignment of responsibilities to the welfare-maximizing federal layer as the centralized regime should be at least as capable of extracting relevant information as any decentralized regime. See Mas-Colell, Whinston and Green (1995), p. 493, for an exposition of the revelation principle.

2.3.4 Exogenously Uniform Policies

A different branch of the literature sticks to Oates' assumption of policy uniformity but replaces the center's efficiency aims by political economy motivations. Crémer and Palfrey (1996) build on a positive framework and assume that individuals face uncertainty with respect to the implementation of policies both at the central and regional layer. The authors derive individual regional preferences for the issue of joining a federation. They assume that a centralized policy outcome must be the same for all member states and argue that the latter fact makes it easier for risk-averse individuals to anticipate a centralized policy outcome. As their major result, regions with polar tastes maintain their sovereignty whereas regions with moderate tastes favor unification.

In a similar contribution, Bolton and Roland (1997) restrict the centralized regime to exogenously uniform redistribution policies for all member states. In equilibrium, centralization occurs only for moderate interregional income disparity. This is due to the fact that large interregional income disparities entail high levels of redistribution. Intuitively, the richer region usually favors a regime of separation.

The explanatory power of those models relying on Oates' assumption of exogenous policy uniformity is challenged by the literature of *distributive politics*. As a major critique, policy uniformity is not explicitly derived from a political process. Indeed, the literature of distributive politics shows that political interaction may bias the distribution of legislative benefits in favor of regions forming *minimum winning coalitions* (e.g. Buchanan and Tullock (1962), Riker and Ordeshook (1973)) and exerting *agenda power* (Baron and Ferejohn (1989)). Drawing on exogenous uniformity as the major source of centralization's deficits, the results in Oates (1972) and similar frameworks, therefore, tend to omit a convincing explanation of why the center fails to account for regional tastes.

Furthermore, the assumption of outright uniform spending levels is not necessarily confirmed empirically. Boadway and Wildasin (1984), pp. 537, e.g. argue that US federal spending efforts depend on various measures like regional per capita income and local tax raising efforts. Referring to federal spending in sub-federal layers, the authors argue that "*[t]he allocations are determined on a state-by-state basis*" (p. 538) and that federal spending, quite generally, entails "*a tendency to treat lower-income states more generously*" (p. 539).

On the other hand, some distributive politics contributions (Weingast (1979), Weingast, Shepsle and Johnsen (1981)) promote the idea that the allocation of legislative benefits may very well turn out uniform.[22] This literature does, by no means, rule out that a uniform allocation may emerge as a *result* of a political process. Yet, imposing exogenous policy uniformity, as does Oates' approach, does not pay attention to the strategical process of policy formation.

2.3.5 Exogenous Advantages

A certain branch of the fiscal federalism literature has built on exogenous regime-specific advantages. Alesina and Spolaore (1997) consider the case of pure local public goods. In their model, the center fails to account for regional preferences as fixed costs of public good provision impede a spatially differentiated level of provision. The optimal degree of decentralization is, therefore, determined by a trade-off between economies of scale and preference heterogeneity. In this line, the paper by Bolton and Roland (1997) assumes that a centralized regime is always more efficient in executing policies. The authors capture this assumption by the fact that centralization entails a parametrized degree of efficiency gains. Referring to the results in Bolton and Roland (1997), as stated above, these exogenous efficiency gains, in fact, constitute the richer region's sole rationale for ever opting for a centralized regime.
Our models shall abstract from exogenous advantages and rather focus on 'non-technical' determinants when considering a regime's potential merits. On the one hand, this is

[22] As discussed below, Lockwood (2002) even demonstrates the latter result in a setting with impure local public goods and spillovers.

due to the fact that the formulation of Oates' (1972) results explicitly rules out exogenous advantages such as cost-savings from centralizing public good provision (see subsection 2.2.4 and the decentralization theorem quoted there).[23] On the other hand, we think that exogenous benefits serve as a rather dissatisfying ingredient for normative policy analysis as any regime's superiority can be attained just by allowing for sufficient benefits.[24] In Alesina and Spolaore (1997), e.g. the normative case for centralization (decentralization) vanishes entirely for sufficiently small (high) fixed costs of public good provision.

2.3.6 The Political Economy of Federal Institutions

The fiscal federalism literature shares a common view of sub-federal policy-making in the sense that decentralization entails a pursuit of regional interests and thus a neglect of interregional externalities. Yet, it is fair to say that the literature has not yet come up with a standard centralized framework. The present subsection of our survey shall, therefore, highlight those recent contributions we consider most adequate for analyzing policy implementation at the federal layer. The respective branch of the literature has focussed on deriving normative guidelines for policy assignment based on political economy frameworks. Indeed, democratic federal institutions are supposed to consist of regional representatives pursuing regional or personal aims. This implies that the aggregation of regional preferences at the central layer does not per se follow a norm of efficiency but is rather subject to political economy considerations. As the latter entail multiple sources of inefficiencies, we shall present the most relevant of these sources and highlight the results that emerge in the respective papers.

[23] Recalling the representation of Oates' model in section 2.2, the respective costs of public good provision public good provision were assumed to be the same for both regimes. This implies that none of the regimes has a purely 'technical' advantage in the production of public goods.

[24] Yet, this is not to say that we generally doubt the existence of federal scale economies. Sandler and Hartley (1995), e.g. argue that the same quality of national defence may be achieved at lower costs if the issue is administrated at the central layer. The authors go on to present some empirical evidence for this assertion.

A common setup of centralized policy-making is characterized by joint taxation, i.e. all regions of the federation bear an equal share of the costs of public good provision. As politically powerful legislators, such as minimum winning coalitions or agenda setters, do not act as benevolent planners, the actual benefits of public good provision may, though, be concentrated in particular localities. This setting, in particular the implementation of a federal cost-sharing scheme, gives rise to a *budget externality*. Regions aim to exploit the latter by pushing for a high level of public good expenditures for their own region. This is due to the fact that regions are levied only a fraction of the associated costs whereas obtaining the whole benefits.

The suggestion that federal cost-sharing arrangements induce inefficiently high levels of local public good provision was prominently pronounced by the distributive politics model of Weingast, Shepsle and Johnsen (1981). Budget externalities are since widely regarded as a major source for inefficient centralized policy-making. In Persson and Tabellini (1994), e.g. the level of centralized local public good provision is subject to regional lobbying efforts. The authors demonstrate the budget externality effect in a framework with symmetric regions by showing that the regional quantity of local public goods is inefficiently high under a centralized regime and, in particular, strictly higher than under a decentralized regime.

Incorporating distributive politics and fiscal federalism literature, Lockwood (2002) analyzes the allocation of public goods in a minimum winning coalitions framework. In the absence of spillovers, public goods are allocated to a bare majority, i.e. public good *benefits are restricted to powerful regions*. This result is well understood from the literature of distributive politics. Yet, the presence of public good spillovers may imply that provision is extended to an even larger number of regions. This is due to the fact that regions within the coalition then enjoy benefits from funding projects in regions outside the coalition. For a member of the coalition, such a funding turns out worthwhile if the received spillover outweighs the member's additional tax share. Centralization may, therefore, entail a desirable allocation of public goods *because* this allocation is favored by politically powerful regions. In a scenario with substantial spillovers, there may even be public good provision in every region. Decentralization, on the other hand, yields efficient results only in the absence of spillovers whereas spillovers entail the familiar underprovision. In line with Oates' guideline, centralization, therefore, turns out preferable for high spillovers whereas decentralization is preferred for per se locally concentrated benefits.

In the political economy framework of Besley and Coate (1999), centralized public good provision is characterized by an uncertainty with respect to the actual composition of the minimum winning coalition. Risk-averse regional voters seek to exploit a budget externality by misrepresenting the region's 'true' valuation for public goods in the course of *strategical delegation*. At the same time, strategical delegation serves as an insurance against *political risk* stemming from ex-post uncooperative behavior at the federal layer. If regions hold similar preferences, there is a tendency towards overspending as each region seeks to attract a larger share of central spending by delegating a public good lover. Results are less clear-cut in case regions differ in the respective preference for public good. Heterogeneity intensifies the perturbing policy variance for individuals. For the low-preference region, exploiting the budget externality conflicts with the desire to understate the region's public good preference, thus giving rise to sophisticated strategical considerations. Under a decentralized regime, the effects of strategical delegation are eliminated, and regional voters elect the 'true' preference-type representative. Yet, decentralized provision, once more, suffers from free-riding. Summarizing their basic results, Besley and Coate (1999) confirm Oates' results.

In an extension of their political economy model, Besley and Coate (1999) capture the idea of cooperative legislative behavior by allowing for welfare-maximizing central legislatures. The authors show that strategical delegation entails severe inefficiencies even if the center pursues efficiency aims. However, the benevolence-based part of the Besley and Coate paper faces the familiar critique concerning the case for decentralization in benevolence-based frameworks of centralized policy-making. Building on this latter part of the Besley and Coate model, Dur and Roelfsema (2003) show that strategical delegation on the part of regional voters can be eliminated by imposing a simple tax scheme on public goods. The reason is that taxes raise the perceived regional costs of public good provision, thus effectively deflating the delegation of high-preference representatives. Given such a taxation scheme, the centralized allocation of public goods is always welfare-maximizing. Not only does this type of taxation scheme[25] induce efficient public good policies; it is even politically feasible as there are mutual gains associated with eliminating the consequences of strategical delegation. As the decentralized regime entails the familiar free-riding inefficiencies, regions, therefore, willingly agree to reap the ubiquitous benefits of centralized public good provision. Whenever the central authority pursues efficiency aims, as for example in Cheikbossian (2000), a mutually beneficial taxation scheme similar to the one derived in Dur and Roelfsema (2003) is supposed to remedy problems of exploiting budget externalities in the course of strategical delegation.[26]

Building on a pure public goods framework, Ellingsen (1998) emphasizes a *neglect of minority preferences* resulting from majority voting in federal legislatures. Contrasting distributive politics models, political power cannot be abused to restrict public good provision to powerful regions due the non-excludabilty characteristic of pure public goods. Yet, employing a majority rule, federal legislatures exclusively account for the federal majority's taste. On the other hand, the familiar externality problem emerges under a decentralized regime. Whereas the consequences of free-riding in terms of retained contribution to the public good are worst for similar preferences, the excessive emphasis on majority preferences militates for substantial preference heterogeneity. Accordingly, heterogeneity (homogeneity) among minority and majority preferences favors a decentralized (centralized) regime.

[25] The explicit scheme is derived on pp. 13-14 of the Dur and Roelfsema (2003) paper.

[26] In Cheikbossian (2000), exogenous policy uniformity mitigates centralization's *common pool* problem.

Concluding the non-exhaustive list of sources for centralization's inefficiencies, let us review two prolific papers that, in a way, depart from this subsection's political economy framework of fiscal federalism. Lülfesmann (2002) analyzes guidelines for policy assignment in a property-rights framework. In his setting, ex-post efficient public good policies can be costlessly negotiated under both a centralized and decentralized regime in the course of generalized Nash-bargaining solutions. Yet, ex-ante investments determine the size of the public good benefits. In the absence of significant spillovers, a centralized regime entails *less incentives to exert value-increasing investments*. This is due to the fact that the 'disagreement' policy entails (does not entail) public good provision under the decentralized (centralized) regime. In a scenario with minor spillovers, investing regions, therefore, accrue a higher proportion of benefits under a decentralized regime whereas the vice versa result emerges for substantial spillovers. Accordingly, small (large) spillovers entail higher incentives to exert investments under decentralization (centralization), thus rendering the respective regime socially preferable.

Finally, a central government might face *less incentives to foster regional tastes* when facing respective disutility of effort. Seabright (1996) shows that regional politicians face better incentives to account for their constituents' needs. On the other hand, centralized policy-making entails an internalization of spillovers. Yet, representatives are tempted to excessively cater the needs of those regions that are most likely responsible for their re-election. Heterogeneity among regions even intensifies the latter effect as politicians are then induced to bunch their efforts on similar regions. Spillovers, on the other hand, imply that a certain level of effort exerted in *one* region may be enjoyed by other regions, too. Increasing the marginal re-election benefits from exerting regional efforts, spillovers and regional homogeneity, therefore, give rise to a centralization of policies whereas decentralization is preferred in vice versa situations.

Notwithstanding the variety of modelling approaches, as reviewed in the present section, the basic Oates (1972) insights emerge in all existing contributions to the literature of fiscal federalism, albeit for different reasons.[27] Yet, these contributions share a one-shot perspective of policy-making. Following the idea that political decision makers usually interact on several occasions, our analysis introduces a repeated game framework of fiscal federalism. Our models aim at both scrutinizing Oates' guidelines and developing new guidelines for further institutional facets, like the number of federal member states, in a dynamic perspective. We shall start our analysis by reviewing Oates' guidelines for assigning spillover policies.

[27] To the best of our knowledge, no contribution has yet challenged Oates' basic insights.

3. Spillovers

3.1 Introduction Chapter 3

Depending on the extent of interregional spillovers, which layer of a federal system should be assigned the right to execute public good policies? Since the seminal work of Oates (1972), it is widely accepted that „local governments will be most efficient for those services [...] which have no significant positive or negative spillovers onto non-residents. For goods with significant [...] spillovers, allocation by the central government is preferred.“[28] In Oates-based frameworks, this result is driven by a trade-off between decentralization's externality problem and policy uniformity imposed on centralized public good provision. In the presence of positive spillovers, regional governments underprovide public goods due to free-riding opportunities. Benevolent central entities rather account for spillovers but fail to cope with interregional preference heterogeneity. Decentralized regimes should, therefore, provide public goods that lack significant externalities, e.g. local public goods, as free-riding entails substantial (negligible) inefficiencies in case of significant (minor) spillovers. Centralization, on the other hand, is favored for high spillovers, e.g. for pure public goods, as the costs of policy uniformity vanish for inherently uniform policies.

Whereas the subsequent literature has widely acknowledged the decentralized framework and its results, Oates' approach has been criticized for leaving out explicit political-economy considerations in modelling federal policy-making. What happens to the guideline for policy assignment if there are rather means but no intrinsic incentives for beneficial policy coordination at the federal layer? Incorporating distributive

[28] Inman and Rubinfeld (1998), p. 11. We shall refer to this statement as the Oates guideline.

politics and fiscal federalism literature, Lockwood (2002) finds that a member of a minimum winning coalition may choose to fund projects in regions outside the coalition if the spillovers for that member outweigh its additional tax burden. In case of significant (marginal) spillovers, provision is, therefore, extended (restricted) to regions outside (inside) the coalition, and centralization (decentralization) is preferred. The latter regime ranking à la Oates has proved robust for its basic tenor prevails in a broad range of convincing public good frameworks. The respective literature includes property rights (Lülfesmann (2002)), asymmetric information (Caillaud, Jullien and Picard (1996)), strategical delegation (Besley and Coate (1999)), and incomplete contracts (Seabright (1996)).

The existing fiscal federalism literature has, though, focussed on analyzing one-shot settings, i.e. political decision-makers are usually predicted to pursue short-run interests. Hence, both centralized and decentralized regimes are likely to entail inefficiencies, and the regime-specific magnitudes determine the ranking among institutions. We, rather, argue that politicians are likely to perceive the benefits from reaping the possible efficiency gains. Furthermore, political decision-makers tend to interact on several occasions, thus motivating a 'more-than-one-shot' perspective of policy-making that may allow for self-sustaining cooperation.[29] The point of departure for this chapter is, therefore, to review the Oates guideline in a repeated game setting. We address the question whether a centralized or decentralized regime is more likely to overcome the above inefficiencies by providing the efficient public good policies. Just like in familiar one-shot frameworks, it can be shown that the answer hinges on the extent of interregional spillovers. Yet, our analysis demonstrates that the transition from a static to a dynamic perspective of policy-making may actually reverse the Oates guideline.

The remainder of this chapter[30] is organized as follows. Section 3.2 sets out the economic environment and derives the benchmark for optimal public good provision. Fol-

[29] See the numbers presented in the introduction to this thesis.

[30] Parts of this chapter are based on Koppel (2004b).

lowing the fiscal federalism literature, section 3.3 derives a rule for optimal policy assignment in a static setting. To this end, we compare public good provision under both a centralized and a decentralized regime in respective one-shot settings. At the federal layer (subsection 3.3.1), public goods are financed via common taxation, and provision ensues in the course of an agenda game played among regional representatives. In the decentralized scenario (subsection 3.3.2), public goods are financed at the regional layer, and regional governments play a non-cooperative game of voluntary public good provision. The regime ranking in subsection 3.3.3 confirms the standard Oates guideline for policy assignment with spillovers.
Section 3.4 introduces repetition of political interaction. In subsections 3.4.1 and 3.4.2, the respective stage games are played over an infinite number of periods. Subsection 3.4.3 derives a guideline for optimal assignment that is based on the regimes' ability to yield the efficient public good policies. This guideline stands at odds with the Oates guideline as the former usually calls for an assignment of policies to the central (decentral) layer if spillovers associated with public good provision are small (large). Section 3.5 concludes.

3.2 Economic Environment

Throughout this chapter, the economy consists of 2 geographically distinct regions. An individual in region $i \in \{1, 2\}$ is represented by utility

$$U_i = \beta \ln [g_i + \phi g_{-i}] + x_i \tag{3.1}$$

where x_i and g_i denote a private good and an impure local public good provided in region i. Immobile regional populations are normalized to unity, respectively. The parameter ϕ measures the degree of interregional spillovers, i.e. residents enjoy symmetric benefits from public goods that are provided in the other region. These spillovers are assumed to satisfy $0 < \phi < 1$. Local public goods are captured by the limiting case of

$\phi \to 0$. Individuals then only care about the public good in their own region. Given the restrictions imposed on ϕ, residents' preferences with regard to the provision of an additional unit of g are biased in favor of their respective home region. Only in the polar case of pure public goods, as characterized by $\phi \to 1$, individuals are indifferent between both public goods. Prices for public goods and private goods are set to p and 1, respectively. Furthermore, individuals in both regions are endowed with the same exogenous income ω. The latter is assumed sufficient to allow for positive private good consumption.

3.2.1 Efficiency Benchmark

For further reference in subsequent sections of this chapter, we derive the benchmark of optimal public good supply. We make use of the fact that for quasi-linear utility, both a *Paretian* analysis and the maximization of public good surplus yield efficient public good quantities.[31] As the aggregate budget constraint reads as

$$\omega_1 + \omega_2 = x_1 + x_2 + p\left(g_1 + g_2\right), \tag{3.2}$$

the efficient public good policies $\{g_1^*, g_2^*\}$ for the utility in (3.1) maximize the aggregate public good surplus[32]

$$S^+ = \beta \ln\left[g_1 + \phi g_2\right] + \beta \ln\left[g_2 + \phi g_1\right] - p\left(g_1 + g_2\right). \tag{3.3}$$

Differentiate (3.3) with respect to g_1 and g_2 and rearrange the respective first-order-conditions to obtain

[31] Appendix 3.A.1 demonstrates this equivalence for the present economic environment.

[32] Throughout this thesis, we drop exogenous incomes when considering surplus and payoff measures, i.e. we consider net values.

$$g_1^* = g_2^* = g^* = \frac{\beta}{p}. \tag{3.4}$$

Straightforward computations are relegated to appendix 5.A.2.[33] Having calculated the efficiency benchmark, let us now turn to the static perspective of institutional policy-making.

3.3 Static Spillover Setting

3.3.1 Centralized Regime

Under a centralized regime, public good policies are decided in a federal legislature consisting of one outcome-motivated representative from each region. The term 'outcome-motivated' indicates that a representative's objective corresponds to the objective of residents in her constituency. Hence, she derives the same utility as the latter from public good provision. As there is no intraregional heterogeneity, we can abstract from considering a possible pre-stage with regional voters choosing their representative in the course of an explicit voting procedure.

The legislative process within one period is characterized as follows. With equal probability, one of the representatives (the agenda setter) is assigned agenda power with respect to a proposal over sets of region-specific public good policies. The status quo policy entails no public good provision at all. Once the proposal has been *put to the vote*, the legislature votes between the proposal and the status quo according to a specified voting rule. This type of legislative decision-making is labelled *closed-rule* voting.[34]

[33] In chapter 5, we extend the analysis to a n-region economy. In order to avoid dispensable calculations, we derive the generalized results there. Evaluating the latter for $n = 2$ yields the results for the present chapter.

[34] Under a closed rule, representatives cannot alter the proposal once it has been put to the vote. Contrasting this procedure, *open-rule* voting allows for an amendment of the original proposal (see Baron and Ferejohn (1989)). Proposals resulting in the course of closed rule voting procedures are often called *take-it-or-leave-it* proposals (see e.g. Persson (1998)). We shall use both terms in a synonymous way.

We assume a unanimity rule, i.e. a policy proposal is accepted iff no representative vetoes its implementation.

Following the standard assumption of fiscal federalism literature, centralized public good provision is financed via identical head taxes, i.e. regional lump-sum burdens amount to

$$\tau_{iC} = \frac{p}{2}\left(g_1 + g_2\right). \tag{3.5}$$

As the regional budget constraint under the centralized regime reads as

$$\omega_i = x_i + \tau_{iC}, \tag{3.6}$$

the regional public good surplus, given the taxation scheme in (3.5), can be expressed as

$$S_{iC} = \beta \ln\left[g_i + \phi g_{-i}\right] - \frac{p}{2}\left(g_i + g_{-i}\right). \tag{3.7}$$

Let a denote the agenda setter's region. In the stage game equilibrium, the agenda setter maximizes her region's surplus subject to the other representative's approval and proposes quantities

$$\{g^a, g^{\neg a}\} = \left\{\frac{2\beta}{p}; 0\right\} \tag{3.8}$$

for her region and the other region, respectively. The other region's representative accepts this proposal as it leaves her better off than the status quo policies.

Substituting (3.8) into (3.3), the aggregate public good surplus under a centralized regime reads as

$$S_C^+ = \beta \left(\ln \frac{2\beta}{p} + \ln \frac{2\beta\phi}{p} \right) - 2\beta. \tag{3.9}$$

As we assume identical preferences for the public good, the agenda equilibrium is symmetric with respect to agenda power, i.e. the aggregate public good quantity and the aggregate surplus under centralization do not depend on who is assigned agenda power.

3.3.2 Decentralized Regime

A regional government consists of an outcome-motivated representative from the respective region. Under a decentralized regime, public goods are provided and financed at the regional level. Hence, regional governments levy regional taxes

$$\tau_{iD} = pg_i. \tag{3.10}$$

As the regional budget constraint under the decentralized regime reads as

$$\omega_i = x_i + \tau_{iD}, \tag{3.11}$$

the regional public good surplus for the taxation scheme in (3.10) can be expressed as

$$S_{iD} = \beta \ln [g_i + \phi g_{-i}] - pg_i. \tag{3.12}$$

Both representatives are assumed to choose policies simultaneously and in a way to maximize (3.12) with respect to their region's contribution. The stage game Nash-equilibrium policies $\{g_1^e, g_2^e\}$, therefore, satisfy

$$g_i^e = \arg\max_{g_i \geq 0} \ S_{iD}\left(g_i, g_{-i}^e\right). \tag{3.13}$$

As is readily shown in appendix 5.A.2, the reaction curves read as

$$g_i = \frac{\beta}{p} - \phi g_{-i}. \tag{3.14}$$

Figure 3.1 exemplifies the reaction curves for $\beta = p = 1$, $\phi = 0.3$ (solid lines), and $\phi = 0.7$ (dashed lines) and depicts the respective symmetric Nash-equilibria.

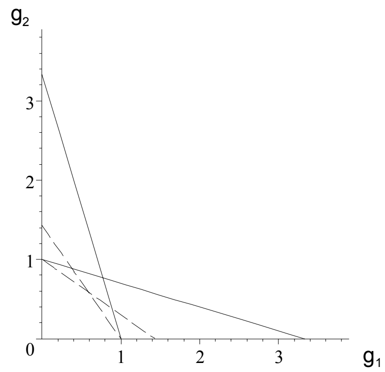


Figure 3.1: Nash-equilibria of the voluntary contribution game

Observe that the optimal level of public goods provided by region i decreases in the level of region $-i$'s contribution, i.e. regional public goods are strategic substitutes. Equate the reaction curves in (3.14) to obtain stage game Nash-equilibrium quantities

$$g_1^e = g_2^e = g^e = \frac{1}{1+\phi}\frac{\beta}{p}. \tag{3.15}$$

Reflecting mutual free riding, the decentralized public good quantities are lower than the efficient policies in (3.4).

Substituting (3.15) into (3.3), the aggregate surplus under a decentralized regime reads as

$$S_D^+ = 2\beta \ln \frac{\beta}{p} - \frac{2\beta}{1+\phi}. \tag{3.16}$$

Inspection of (3.16) reveals that S_D^+ increases in ϕ, i.e. the decentralized regime's absolute performance increases spillovers. Once more, this information has no meaning in itself as a sensible guideline for policy assignment is supposed to reflect how a regime performs compared to the other regime.[35] Let us, therefore, compare the regimes' relative performance.

3.3.3 Regime Ranking in the Static Spillover Setting

Depending on the extent of interregional spillovers, which regime should be assigned the right to execute public good policies from the one-shot perspective? The following proposition is readily established.

Proposition 2 *In the static setting, there exists a critical spillover level $\bar{\phi}$ in a way that a centralized (decentralized) regime is surplus-superior for spillover levels greater (lesser) than $\bar{\phi}$.*

Proof. Denote the surplus gap, i.e. the difference between (3.9) and (3.16), as

$$S_C^+ - S_D^+ = \beta \left(2\ln 2 + \ln \phi - \frac{2\phi}{1+\phi} \right), \tag{3.17}$$

and observe that (3.17) converges to $-\infty$ for $\phi \to 0$ and to $2\ln 2 - 1 > 0$ for $\phi \to 1$. Hence, the surplus gap is negative for small spillovers and positive for large spillovers. Furthermore, define $\bar{\phi}$ so that $S_C^+ \left(\bar{\phi}\right) = S_D^+ \left(\bar{\phi}\right)$. Finally, differentiate (3.17) with respect to ϕ to obtain $\frac{\partial\left(S_C^+ - S_D^+\right)}{\partial \phi} = \frac{\beta(1-\phi)}{(1+\phi)\phi} > 0$. ■

[35] Note, for example, that the surplus under a centralized regime increases in ϕ, too.

Two inefficiencies drive the results in proposition 2. A decentralized regime entails free-riding among regions. The degree of underprovision as well as the resulting efficiency losses turn out more severe as spillovers increase. The externality and thus decentralization's inefficiencies disappear, though, in the limiting case of infinitesimal spillovers.

On the other hand, centralization induces distortions because the agenda equilibrium merely reflects the agenda setter's preference for the public good.[36] Yet, as there is no preference heterogeneity among regions, the respective distortion decreases unambiguously in spillovers and disappears in the limiting case of pure public goods.

Figure 3.2 illustrates the results in proposition 2 by depicting (3.17) for $\beta = 1$.

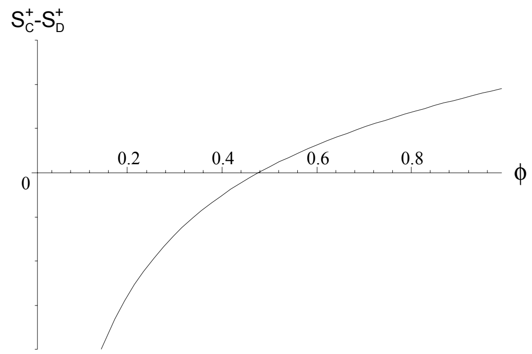


Figure 3.2: Surplus gap in the static spillover setting

Note that proposition 2 is in line with the Oates guideline for policy assignment, i.e. substantial (marginal) spillovers favor (reject) centralization. In an Oates framework, though, centralization always outperforms decentralization as long as there is no heterogeneity among regions. The simple reason is that the uniform policy employed by

[36] This finding supports the view that "*[l]ocally chosen representatives may place parochial interests above the collective interest in efficient public good provision.*" (Inman and Rubinfeld (1997), p. 61).

the benevolent decision maker does not encounter inefficiencies associated with a neglect of regional heterogeneity whereas decentralization's free-riding inefficiency still emerges. In an Oates model, decentralization, therefore, requires heterogeneity to ever dominate centralization. In our model, the Oates guideline likewise emerges in a static setting with identical preferences. This is due to the fact that centralization's inefficiencies rather stem from political economy considerations, i.e. from the distorted representation of regional preferences in the course of an asymmetry of political power.

As was shown in the proof of proposition 2, the surplus gap increases monotonically in ϕ. This monotonicity is not a standard result of static fiscal federalism models. Yet, as was shown in section 2.3, the existing literature has already brought up vast support for the polar results by stating that a centralized (decentralized) regime should be assigned policies entailing substantial (marginal) spillovers.[37]

Our basic purpose for this section was to build a static framework that is able to replicate the standard Oates guideline. Building on this static framework, the following section shows that this very guideline may be reversed in a repeated game setting.

3.4 Repeated Spillover Setting

Fool me once, shame on you.
Fool me twice, shame on me.
attributed to the Chinese

The purpose for this section is to analyze an optimal assignment of spillover policies in a dynamic framework. We shall now ask whether efficient public good policies are easier to sustain under a decentralized or under a centralized regime. This question is somewhat different from the initial static game problem. In particular, it cannot be addressed at all in a static model. The intuitive reason is that there is generally no

[37] In this context, Rubinfeld (1987) shows that a decentralized provision of local public goods yields efficient results in the static perspective in case the regional median voter corresponds to the average regional individual.

efficiency-sustaining cooperative behavior in non-cooperative one-shot models.[38] We shall introduce a regime ranking that reflects the layers' ability to provide the efficient public good policies in a dynamic setting. Based on the theory of repeated games, we derive necessary regime-specific conditions for yielding efficiency-sustaining cooperative outcomes and analyze the spillover's impact on the ability to maintain cooperation.

In the repeated setting, representatives play the respective games of subsections 3.3.1 and 3.3.2 over an infinite number of periods. The representatives share perfect recall, i.e. in period t, both of them are fully aware of all previous strategy choices comprised in the game's history

$$h_t = \left\{ (g_1, g_2)_1, \ldots, (g_1, g_2)_{t-1} \right\}. \tag{3.18}$$

Furthermore, representatives have a common discount factor $0 < \delta < 1$ that measures the degree of patience with regard to future payoffs. In order to derive clear-cut results, we abstract from both polar (im)patience. Binding contracts are not possible. Otherwise, representatives were able to enforce cooperation via exogenous mechanisms. We are, though, interested in finding endogenous mechanisms that enable self-enforcing cooperation.

Following the standard literature on infinitely repeated games (e.g. Friedman (1971)), we assume that representatives employ *trigger-strategies* in order to resolve short-run incentives to deviate from cooperation.

3.4.1 The Dynamics of Centralization

For the repeated game of centralized decision-making, suppose that, just like in the stage game of subsection 3.3.1, agenda power is assigned with equal probability in the first period. In subsequent periods, agenda power rotates among representatives, i.e.

[38] Pecorino (1999) makes this point in a repeated game of voluntary public good provision.

whoever is assigned agenda power in the first period returns to agenda power in the odd periods whereas the other region's representative holds power in the even periods.[39] This type of modelling is inspired by European Council decision-making procedures. The latter feature a rotating presidency, i.e. "*each EU country in turn takes charge of the Council agenda and chairs all the meetings for a six-month period, promoting legislative and political decisions*".[40]

Let us now turn to the problem of maintaining cooperation, considering the case of cooperative legislative behavior. If both representatives employ trigger-strategies, the representative that is assigned agenda power in the first period proposes the cooperative quantities (3.4). A representative holding agenda power in period $t > 1$ proposes the cooperative policies if all agenda setters did so in all previous periods. In case of a whatsoever deviation from the cooperative quantities, agenda setters propose the stage game equilibrium quantities (3.8) in all subsequent periods, i.e. there is infinite Nash-reversion. Furthermore, representatives exposed to agenda power accept a proposal if it leaves them at least indifferent to the status quo policy of no public good provision.

The trigger-strategy for a representative from region i can be described by:

$$\begin{array}{ll} \text{propose } (g^*, g^*) & \text{if } i = a \ \wedge \ t = 1 \\ \text{propose } (g^*, g^*) & \text{if } i = a \ \wedge \ t > 1 \ \wedge \ h_t = \left\{ (g^*, g^*)_1, \ldots, (g^*, g^*)_{t-1} \right\} \\ \text{propose } (g^a, g^{\neg a}) & \text{if } i = a \ \wedge \ t > 1 \ \wedge \ h_t \neq \left\{ (g^*, g^*)_1, \ldots, (g^*, g^*)_{t-1} \right\} \\ \text{accept proposal} & \text{if } S_{iC}^{PR} \geq S_{iC}^{SQ}, \end{array} \tag{3.19}$$

The superscripts PR and SQ denote proposal and status quo policies, respectively. The present repeated game of centralized public good provision differs from standard repeated games as representatives play two different stage games. We shall, therefore,

[39] Hence, the randomized assignment of agenda power now rather serves to resolve the first period's deadlock.

[40] http://europa.eu.int/institutions/council/index_en.htm#presidency, Homepage of the European Union, last visit: January, 29th, 2004. As presented in chapter 5, the results derived in the current subsection carry over to a n-region economy.

first of all derive a general necessary condition for maintaining cooperation in this game.

Given the strategies in (3.19), representatives receive cooperative payoffs π^* in all periods if the legislature pursues cooperation.[41] If an agenda setter chooses to defect from cooperation, she cannot do better than to propose stage game equilibrium policies. Bearing in mind the triggered retaliation, she proposes the quantities (3.8) and earns payoffs π^a in the period of defection as well as in any other subsequent period that she is assigned agenda power, but she receives payoffs $\pi^{\neg a}$ in all of the other periods. Accordingly, $\pi^{\neg a}$ and π^a alternate in periods subsequent to defection.

Cooperation can be sustained if the discounted payoffs from defection do not exceed the discounted payoffs from cooperation. Straightforward computations[42] show that the necessary condition for maintaining cooperation in the repeated centralized game reads as

$$\delta\left[\pi^* - \pi^{\neg a}\right] \geq \pi^a - \pi^*. \tag{3.20}$$

Next, define δ^C as the critical value of δ in a way that (3.20) is satisfied as a strict equality. This critical discounting parameter can then be expressed as

$$\delta^C = \frac{\pi^a - \pi^*}{\pi^* - \pi^{\neg a}}. \tag{3.21}$$

Recall that $\delta \in (0, 1)$. Equation (3.21) then implies that the payoff ranking must satisfy $\pi^a > \pi^* > \pi^{\neg a}$. Intuitively, the notion of agenda power, in particular the *ultimatum game*-like structure of policy-making, implies such a payoff ranking.[43]

[41] Due to the payoff symmetry, we drop the index i.

[42] See appendix 3.A.2.

[43] The genuine treatment for a one shot ultimatum game deals with the problem of splitting a fixed amount of money among two agents. One of the agents (the proposer) offers a certain split. The other agent (the responder) can choose to either accept or deny the proposal. Acceptance implies to

Cooperation can be maintained as a Nash-equilibrium of the repeated game if the necessary condition for maintaining cooperation is satisfied for both representatives. As the payoff structure is symmetric, the critical discounting parameter is the same for both representatives, i.e. cooperation can be maintained if $\delta \geq \delta^C$.

As the volatility of political power in this subsection induces an asymmetry of stage games, condition (3.20) differs from standard conditions resulting from an employment of trigger-strategies in standard repeated games (see e.g. the next subsection).

In order to obtain the specific value for δ^C, first insert (3.8) into (3.7). An uncooperative representative holding agenda power in a certain period then receives payoffs

$$\pi^a = \beta \ln \frac{2\beta}{p} - \beta \tag{3.22}$$

whereas the representative that is exposed to agenda power receives

$$\pi^{\neg a} = \beta \ln \frac{2\beta\phi}{p} - \beta. \tag{3.23}$$

If an agenda setter abstains from using agenda power and rather proposes the efficient quantities of (3.4), payoffs amount to

$$\pi^* = \beta \ln \frac{\beta\,(1+\phi)}{p} - \beta \tag{3.24}$$

split the money according to the proposal whereas rejection leaves both agents empty-handed. In the *subgame perfect* prediction for such an ultimatum game, the proposer obtains (essentially) the whole stake (see Selten (1975)).
Güth, Schmittberger and Schwarz (1982) test the one-shot ultimatum bargaining empirically. They find that the actual split is biased substantially in favor of the proposer. In line with subsequent ultimatum experiments (see Roth (1995) for an overview), the authors conclude from the data that responders are more prone to reject an 'unfair' proposal if their respective costs, in terms of lost payoff, are rather small (Güth, Schmittberger, and Schwarz (1982), p. 384). Indeed, these costs of rejection are rather immense in our agenda model. The latter is, therefore, best-suited for capturing situations that are characterized by substantial default costs.

for both representatives.

There is a point worth mentioning. Referring to the potential benefits from employing a high quorum for policy implementation, it is sometimes argued that "*decisions in supranational bodies often require unanimity, thus forcing legislators to cooperate.*"[44] Our centralized framework rather exemplifies that the quoted implication does not necessarily emerge in a political economy based model. Employing a unanimity rule, we demonstrate that an agenda setter may well be able to implement her favored policies. Indeed, our static setting shows that a unanimity rule may even entail an utmost uneven allocation of benefits as is the case for low spillovers.[45] Hence, there is no straightforward correlation between unanimity voting and the distribution of legislative benefits.

In our framework, the case for cooperation arises if the latter is self-enforcing in the sense that, once regions have agreed on the cooperative scheme, none of the regions faces a unilateral incentive to deviate from it. Observe that $\pi^a > \pi^* > \pi^{\neg a}$, i.e. cooperation can never be an equilibrium of the stage game. Yet, representatives do better under a cooperative legislature, as the latter entails higher average payoffs ($\pi^* > \frac{1}{2}\pi^a + \frac{1}{2}\pi^{\neg a}$). Specifically, this result is due to the fact that (i) the average regional public goods quantities under an uncooperative legislature equal the cooperative quantities and (ii) the utility in (3.1) implies risk-aversion and thus a preference for consumption smoothing over time.

Equation (3.21) implies that, in order to overcome short-run incentives to abuse agenda power, a critical degree of patience must be met. Hence, insert (3.22), (3.23), and (3.24) into (3.21) to obtain

[44] Dur and Roelfsema (2003), p. 2. The authors justify their framework of benevolent centralized policy making by this statement.

[45] Recall that 3.22 and 3.23 represent the stage game equilibrium payoffs.

$$\delta^C = \frac{\ln \frac{2}{1+\phi}}{\ln \frac{1+\phi}{2\phi}}. \tag{3.25}$$

What impact do spillovers now have on the legislature's ability to maintain cooperative outcomes? We state the following proposition.[46]

Proposition 3 *Under the centralized regime, (i) the efficient public good quantities can be provided for sufficiently small spillovers, (ii) the likeliness to provide the efficient public good quantities decreases in spillovers, and (iii) the efficient public good quantities cannot be provided for sufficiently large spillovers.*

The proof is somewhat tedious and therefore relegated to appendix 3.A.3. It can be shown that δ^C increases monotonically in ϕ, i.e. cooperation becomes less likely sustainable as spillovers increase. Furthermore, $\lim_{\phi \to 0} \delta^C = 0$ and $\lim_{\phi \to 1} \delta^C = 1$, where $0 < \delta < 1$ holds by assumption.

In order to capture the underlying intuition, consider first a stage game policy analysis. The one-shot equilibrium (3.8) merely reflects the agenda setter's preference for the public good. For local public goods ($\phi \to 0$), the other region is excluded completely from legislative benefits. Yet, the respective distortion decreases in spillovers and vanishes in the limiting case of pure public goods ($\phi \to 1$) because the region that is exposed to agenda power increasingly enjoys spillovers from the agenda setter's region.

Consider now the repeated game setting. Observe that the public goods are provided at the same (fixed) aggregate level both under a cooperative and uncooperative legislature, whereas an uncooperative agenda setter always channels twice the cooperative quantity of public goods to her own region. Accordingly, the limiting case of no spillovers ($\phi \to 0$) entails maximum gains from abusing agenda power because the agenda setter then enjoys no benefits at all from public good provision in the other region. Yet, these gains

[46] Proposition 3 likewise emerges if agenda power is assigned randomly with equal probability at the beginning of *each* stage game in the repeated centralized game.

are bounded above because there are still positive benefits in the cooperative situation. On the other hand, being exposed to agenda power implies a complete exclusion from legislative benefits. This effect entails infinite costs from abusing agenda power and, therefore, prevails even for utmost impatient representatives. Hence, cooperation can be sustained for sufficiently small spillovers.

An increase in spillovers entails two opposing effects. Facilitating efficiency-sustaining cooperation, the gain from abusing agenda power, as measured by $\pi^a - \pi^*$, decreases in spillovers. This is due to the fact that an agenda setter now more and more enjoys public good provision in the other region. Hence, she forfeits less surplus by allocating public goods to the other region, too. On the other hand, the costs of defection, $\pi^* - \pi^{\neg a}$, decrease even stronger in spillovers because the region that is exposed to agenda power enjoys more and more benefits from provision in the agenda setter's region, thus suffering disproportionately less from an uncooperative legislature. In the limiting case of pure public goods ($\phi \to 1$), the difference between gains and costs from abusing agenda power, eventually, vanishes completely because a region can no longer be excluded from legislative benefits. As a consequence of discounting, an agenda setter cannot resist to realize the gains, i.e. cooperation cannot be sustained at all for $\phi \to 1$.

The findings in proposition 3 exhibit an interesting analogy to results from the universalism literature of distributive politics. In Weingast's (1979) minimum winning coalitions model, representatives face uncertainty with respect to the actual composition of the coalition. Fearing the consequences of being excluded from legislative benefits, representatives comply with a norm of cooperative benefit distribution whenever they average higher payoffs under a cooperative legislature. In a static setting, any incentive to cooperate is, though, viable only from an ex-ante perspective.[47] Weingast (p. 253) therefore adds that "a universalistic rule must [...] give individual legislators an incentive to follow the rule at all times." In this regard, we show that the repetition

[47]Note that $\pi^* > \frac{1}{2}(\pi^a + \pi^{\neg a})$ is always satisfied in our setting. Yet, contrasting the results in Weingast (1979), this condition is not sufficient for achieving cooperative outcomes.

inherent in legislative interaction, in particular the volatility of political power, may yield ex-post-viable incentives for cooperative behavior by entailing a threat of punishing any pursuit of short-run interests. Measured by the consequences of being excluded from legislative benefits, this very threat is most (least) effective for local (pure) public goods as legislative benefits then can (cannot) be forced to concentrate within specific regions.

The strategies in (3.19) yield a subgame perfect Nash-equilibrium.[48] This is a desirable property as the following deliberation highlights. Consider the following alternative strategies. Agenda setters always propose cooperative quantities, and representatives exposed to agenda power reject any other than the cooperative proposal. Certainly, cooperation is always a Nash-equilibrium under these strategies. Facing the threat of rejection, agenda setters cannot do better than to propose cooperative quantities. On the other hand, representatives exposed to agenda power cannot do better than to accept the cooperative quantities. These strategies are, obviously, mutually best responses and cooperation, therefore, constitutes a Nash-equilibrium of the repeated game. Yet, the strategies employed to sustain cooperation, in particular the announced punishment for defection from cooperation, build on *incredible threats*. Once an agenda setter has launched another proposal, say the agenda quantities of (3.8), it is not in the interest of the responder to turn down this proposal, as she actually earns a lower payoff by rejecting the proposal. Her threat of turning down the proposal is, therefore, not credible. In the subgame perfect equilibrium, the agenda setter anticipates that a responder will accept any proposal that leaves her at least as well off as the status quo. In essence, subgame perfection implies that strategies not only induce Nash-equilibria in the whole game but also in every subgame.[49]

In order to derive a sensible regime ranking for this section, let us now analyze the

[48] We employ subgame perfect strategies in all subsequent chapters.

[49] See Binmore (1992), pp. 47-48, for an instructive introduction into the concept of subgame perfection.

decentralized regime in a repeated game setting.

3.4.2 The Dynamics of Decentralization

In the repeated decentralized setting, representatives play the stage game of subsection 3.3.2 over an infinite number of periods and, like in subsection 3.4.1, employ trigger-strategies in order to maintain efficient outcomes.[50]

Deciding on region i's contribution, the representative from that region chooses to provide the efficient quantity (3.4) in the first period of the repeated game. In subsequent periods, she continues to provide the efficient amount if all representatives did so in all previous periods, i.e. if the game's history records nothing but cooperative quantities. Whenever the history records a different entry, there is infinite Nash-reversion, and representatives contribute the stage game Nash-equilibrium quantities (3.15).

The trigger-strategy for a representative from region i can, therefore, be described by

$$g_i = \begin{cases} g^* & \text{if } t = 1 \\ g^* & \text{if } t > 1 \ \wedge \ h_t = \left\{ (g^*, g^*)_1 , \ldots , (g^*, g^*)_{t-1} \right\} \\ g^e & \text{else} \end{cases} . \tag{3.26}$$

If a representative rather defects from cooperation, she chooses her contribution to maximize her short run advantage whilst anticipating the other region's cooperative contribution in the period of defection as well as the mutual return to stage game Nash-equilibrium policies in all subsequent periods. The optimal contribution g_i^d for a defecting representative is, therefore, characterized by

$$g_i^d = \arg\max_{g_i \geq 0} \ \{ \beta \ln [g_i + \phi g^*] - p g_i \} . \tag{3.27}$$

[50] See Pecorino (1999) for a recent application of trigger strategies in the context of voluntary contribution games with pure public goods.

Solving (3.27), a defecting representative contributes

$$g_1^d = g_2^d = g^d = \frac{(1-\phi)\,\beta}{p}. \tag{3.28}$$

The straightforward algebra is relegated to appendix 5.A.2.

Given the trigger-strategies in (3.26), a representative receives cooperative payoffs π^* in all periods if there is mutual cooperation. If, on the other hand, a representative defects, she receives payoffs π^d in the period of defection and stage game Nash-equilibrium payoffs π^e afterwards.[51]

Again, cooperation can be sustained if the discounted payoffs from defection do not exceed the discounted payoffs from cooperation. The corresponding well-known condition for maintaining cooperation in repeated games reads as[52]

$$\frac{\delta}{1-\delta}\left[\pi^* - \pi^e\right] \geq \pi^d - \pi^*. \tag{3.29}$$

Let δ^D denote the critical value of δ so that the latter condition is satisfied as a strict equality. Straightforward manipulation then yields the familiar critical discounting parameter

$$\delta^D = \frac{\pi^d - \pi^*}{\pi^d - \pi^e}. \tag{3.30}$$

Again, cooperation can be maintained if $\delta \geq \delta^D$. Let us now consider the cooperative payoffs. If representatives overcome the free riding problem and provide the efficient quantities (3.4), both representatives receive cooperative payoffs

[51] A standard result for infinitely repeated games reveals that, due to stationarity, a defecting agent always chooses to defect in the first period. See e.g. Friedman (1990), pp. 88-89.

[52] The familiar algebra is found in appendix 3.A.2. See, e.g. Shapiro (1989), p. 364, for a similar exposition.

$$\pi^* = \beta \ln \frac{\beta (1+\phi)}{p} - \beta \tag{3.31}$$

that, intuitively, correspond to (3.24). Furthermore, inserting (3.28) as well as the other region's cooperative contribution into (3.16), a defecting representative earns payoffs

$$\pi^d = \beta \ln \frac{\beta}{p} - \beta (1-\phi) \tag{3.32}$$

in the period of defection. Finally, insertion of (3.15) into (3.16) yields the stage game equilibrium payoffs

$$\pi^e = \beta \ln \frac{\beta}{p} - \frac{\beta}{1+\phi}. \tag{3.33}$$

In order to obtain the specific value of δ^D, insert (3.31), (3.32), and (3.33) into (3.30). Straightforward manipulations then yield

$$\delta^D = \frac{\phi - \ln (1+\phi)}{\frac{\phi^2}{1+\phi}}. \tag{3.34}$$

What does this term reveal about the correlation between spillovers and efficient decentral public good provision? It enables us to state the following proposition.[53]

Proposition 4 *Under the decentralized regime, the likeliness to provide the efficient public good quantities decreases in spillovers.*

It can be shown that δ^D increases monotonically in spillovers, i.e. cooperation in the decentralized setting is harder to sustain for large spillovers. On the one hand, the

[53] The proof is relegated to appendix 3.A.4.

costs of defection, as indicated by the degree of underprovision in the stage game equilibrium compared to cooperation, increase in spillovers (simply compare (3.4) to (3.15)). However, the gain from defection, as indicated by the degree of retained contribution, increases even stronger (compare (3.28) to (3.4)).

Contrasting the centralized setting, there now exist admissible values of δ in a way that cooperation can be maintained for large spillovers ($\lim_{\phi \to 1} \delta^D = 2 - \ln 4 < 1$). On the other hand, cooperation now requires some patience in order to be maintained for small spillovers)observe that $\lim_{\phi \to 0} \delta^D = \frac{1}{2}$).

The next subsection analyzes both regimes' relative merits in the repeated game setting.

3.4.3 Regime Ranking in the Repeated Spillover Setting

Depending on the extent of interregional spillovers, which regime should execute public good policies in the repeated game setting? Obviously, the answer to this question hinges on the ability to maintain efficient public good quantities. Let us, therefore, first state the following proposition.

Proposition 5 *In the repeated game setting, there exists a critical spillover level $\hat{\phi}$ in a way that the efficient public good policies are easier to sustain under a centralized (decentralized) regime for spillovers lesser (greater) than $\hat{\phi}$.*

Proof. Recall that both δ^C and δ^D increase monotonically in ϕ. Furthermore, recall that $\lim_{\phi \to 0} \delta^C < \lim_{\phi \to 0} \delta^D$, i.e. $\delta^C < \delta^D$ holds for small spillovers. On the other hand, $\lim_{\phi \to 1} \delta^D < \lim_{\phi \to 1} \delta^C$, i.e. $\delta^C > \delta^D$ holds for large spillovers. Accordingly, there exists a critical spillover level $\hat{\phi}$ so that $\delta^C \left(\hat{\phi} \right) = \delta^D \left(\hat{\phi} \right)$. ■

In figure 3.3, the critical spillover level $\hat{\phi}$ is depicted by the intersect of the critical discounting parameters (3.25) and (3.34).

Consider $\phi < \hat{\phi}$. Whenever cooperation can be sustained under a decentralized regime, it can be sustained under a centralized regime, too. Furthermore, there exists a range

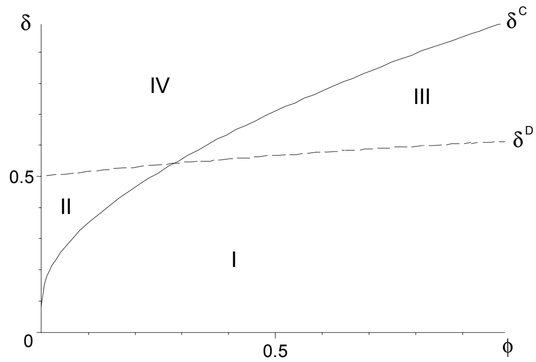


Figure 3.3: Regime ranking in the repeated spillover setting

of δs in a way that cooperation can be sustained under centralization but not under decentralization. Hence, cooperation is easier to sustain under centralization for $\phi < \hat{\phi}$. Vice versa, cooperation is easier to sustain under decentralization for $\phi > \hat{\phi}$.

What guideline for policy assignment can be drawn from these results? From a stage game perspective, the regime ranking is readily established. Recalling the regime ranking in subsection 3.3.3, there exists a critical level of spillovers $\bar{\phi}$ in a way that the decentralized (centralized) regime is surplus-superior for spillovers smaller (greater) than $\bar{\phi}$. From the repeated game perspective, the regime ranking hinges on the ability of sustaining cooperation. Hence, we have to account for both spillovers and the degree of discounting and differentiate between three cases. Referring to figure 3.3, area I depicts those configurations of δ and ϕ that are characterized by $\delta < \min\left\{\delta^D, \delta^C\right\}$. In this case, cooperation can neither be sustained under a centralized nor under a decentralized regime. Falling back to the stage game equilibria (3.8) and (3.15), the standard Oates guideline prevails yet again.
For medium δs, i.e. for $\min\left\{\delta^D, \delta^C\right\} \leq \delta < \max\left\{\delta^D, \delta^C\right\}$, only one regime yields efficient outcomes whereas the other entails the familiar efficiency losses associated with the stage game equilibrium. Accordingly, the centralized (decentralized) regime is surplus-superior for configurations of δ and ϕ that are located in area II (III). Re-

versing the Oates guideline, public good policies should then be assigned to the central (regional) layer in case of spillovers smaller (larger) than $\hat{\phi}$.

Finally, for $\max\left\{\delta^D, \delta^C\right\} \leq \delta$, the efficient outcomes can be sustained under both regimes (area IV). Hence, no regime entails a higher surplus, and there is no straightforward guideline for policy assignment in this case. Nevertheless, we argue that there are plausible reasons to stick to the guideline that emerges for medium δs. On the one hand, following the *subsidiarity principle* of the Maastricht treaty, policies should be centralized iff there is an actual benefit from doing so. Taking this principle literally, policies should not be centralized if both regimes perform equally well. Indeed, whenever a regime yields efficient outcomes for medium δs, it likewise yields efficient outcomes for large δs and, therefore, performs at least as good as the other regime. Now think of problems such as a small uncertainty with respect to δ, i.e. the exact degree of patience may not be observable. Suggesting a different guideline for medium and large δs then runs the risk of suffering inefficiencies for δs in the neighborhood of $\max\left\{\delta^D, \delta^C\right\}$ without ever yielding an efficiency gain. This argument breaks the tie in favor of the regime that was already assigned policies for medium δs. Intuitively, there is no reason to jeopardize cooperation by changing the assignment rule if there is no benefit from doing so.[54]

Summarizing our above results, the Oates guideline prevails iff the stage game perspective proves relevant, as is the case for fairly impatient representatives (area I). Yet, the Oates guideline is reversed for a broad range of circumstances (areas II, III, and IV) in the repeated game setting.

[54] Although this plausibility argument is likewise based on robustness with respect to a small uncertainty, it should not be confused with the *trembling-hand* refinement concept for Nash-equilibria (Selten (1975)). The latter rather employs small probabilities of faulty strategy choices.

3.5 Conclusion Chapter 3

This chapter reviewed the Oates guideline for assigning spillover policies to federal layers in both a static and a repeated game setting. In the static setting, the standard Oates guideline for policy assignment is confirmed. In the repeated setting, we addressed the question whether a centralized or a decentralized regime is more likely to yield efficient outcomes. Building on the respective one-shot games, our key findings show that the efficient policies are easier to sustain under centralization (decentralization) if spillovers are small (large). The emerging regime ranking challenges the Oates guideline by showing that a centralized regime usually yields a higher (lower) surplus than decentralization if spillovers are small (large). These results are driven by the effect of spillovers on the payoffs π^*, π^a, and $\pi^{\neg a}$ in the centralized setting and on the payoffs π^*, π^d, and π^e in the decentralized setting.

Our results (proposition 3) give a possible explanation for the *universalistic* distribution of local public goods often found in real-life legislatures (see, e.g. the literature cited in Weingast (1979)). In the absence of spillovers, exclusion from public good provision implies complete exclusion from legislative benefits. If representatives are exposed to political risk, say in terms of changing majorities, exclusion then serves as a severe punishment for deviating from a cooperative benefit distribution. If representatives hold a preference for benefit smoothing over time, the threat of exclusion induces a compliance with cooperation. Spillovers, on the other hand, rather mitigate the punishment effect and hamper cooperation.

Unfortunately, a clear-cut regime ranking is rather unlikely to emerge if we allow for aspects of interregional heterogeneity. The results in Ellingsen (1998) indicate that the equilibrium structure of voluntary regional contributions to a public good is extremely sensitive with respect to interregional heterogeneity of preferences and/or size.[55] In

[55] Ellingsen (1998) employs quasi-linear utility and shows that only the region with the higher aggregate marginal willingness to pay contributes under a decentralized regime whereas the other region free-rides completely.

this regard, marginal asymmetries entail discontinuities of both regional contributions and (stage game) equilibrium surplus. These discontinuities are rather likely to produce ambiguous effects on the ability to sustain efficient outcomes in our decentralized setting.

Let us, finally, consider the consequences of introducing a majority rule to our 2-region framework of centralized policy-making. As Besley and Coate (2003), p. 2619, argue, each representative can then be thought of as a separate minimum winning coalition. Following this argument, the stage game policy-outcome in our model is the same under a majority rule. Capturing volatility of political power in a way that representatives belong to the minimum winning coalition only in certain periods, our results of centralized policy-making likewise emerge if the legislature applies a majority rule.
With regard to more general preferences, we should expect a negative correlation between quorum size and agenda power in terms of discretionary policy implementation (see, e.g. Bednar, Ferejohn and Garrett (1996), proposition 1). From a one-shot perspective, reducing the quorum is, therefore, likely to increase the disparity of legislative benefits. From a dynamic perspective, though, reducing the quorum entails rather opposing effects. Ignoring the needs of the minority, an agenda setter is able to reap *some* more legislative benefits whereas cooperative outcomes do not depend on the legislative rule employed. Hence, the gain from abusing agenda power is (weakly) higher under a majority rule. On the other hand, a representative faces *complete* exclusion from legislative benefits in case she is exposed to agenda power. Accordingly, the costs from abusing agenda power increase, too. Considering the magnitude of both effects, the costs of abusing agenda power are likely to prevail. Hence, reducing the quorum is supposed to serve as an efficiency-sustaining feature of policy-making in a dynamic perspective. Further research might, therefore, consider the impact of legislative rules on the prospects for sustaining legislative cooperation in more detail.

The results build on an absence of additional factors that might impede cooperation in repeated games. In this regard, some well-known obstacles like renegotiation-proofness

(Farrell and Maskin (1989)) or informational problems (Green and Porter (1984)) might inhibit cooperation in repeated games. In this case, the stage game equilibria prove the viable prediction, and the Oates guideline prevails yet again. By a standard backward induction argument, the same is true for a finite horizon game structure.

If there are no additional obstacles impeding cooperation in repeated games, the repeated game perspective reproduces the Oates guideline iff stage game equilibrium policies prove the appropriate prediction, i.e. if representatives attach a high weight to short-run considerations. Otherwise, the Oates guideline is reversed. Our results, therefore, certainly highlight the importance of considering the dynamics of political interaction in more detail.

Recalling proposition 1, the Oates guideline likewise deals with assigning public good policies contingent on interregional heterogeneity. The next chapter, therefore, applies the present framework to a setting with asymmetric regional preferences and scrutinizes the respective guidelines in a repeated game perspective.

3.A Appendix Chapter 3

3.A.1 Public Good Surplus and Paretian Analysis

The Pareto-program for the economic environment of section 3.2 can be described by choosing an allocation of $x_1,\ x_2,\ g_1$, and g_2 so as to maximize $U_1 = \beta \ln [g_1 + \phi g_2] + x_1$ subject to the constraints

$$U_2 = \beta \ln [g_2 + \phi g_1] + x_2 \geq \bar{U}_2, \tag{3.35}$$

i.e. utility in region 2 must not fall short of an assigned reservation utility, and

$$\omega_1 + \omega_2 = x_1 + x_2 + p\,(g_1 + g_2)\,, \tag{3.36}$$

stating that overall expenditures for private good consumption and public good supply must not surpass aggregate income. The corresponding Lagrange-program can be expressed as

$$\max_{x_1, x_2, g_1, g_2, \lambda, \gamma} L = U_1 + \lambda \left[U_2 - \bar{U}_2\right] + \gamma \left[\omega_1 + \omega_2 - x_1 - x_2 - p\,(g_1 + g_2)\right] \tag{3.37}$$

The familiar first-order conditions for private good consumption read as

$$\frac{\partial L}{\partial x_1} = \frac{\partial U_1}{\partial x_1} - \gamma = 0 \quad \text{and} \quad \frac{\partial L}{\partial x_2} = \lambda \frac{\partial U_2}{\partial x_2} - \gamma = 0. \tag{3.38}$$

For quasi-linear utility, the marginal utility for private good consumption $\frac{\partial U_i}{\partial x_i}$ is simply 1, implying that both Lagrange-multipliers in (3.38) take a value of 1. Consequently, the maximand in (3.37) can be expressed as

$$\beta \ln [g_1 + \phi g_2] + \beta \ln [g_2 + \phi g_1] - p\,(g_1 + g_2) - \bar{U}_2 + \omega_1 + \omega_2 \tag{3.39}$$

Dropping the constant income and reservation utility terms, this expression represents the aggregate public good surplus. For quasi-linear utility, Paretian analysis and maximization of aggregate public good surplus, therefore, both yield the efficient level of public good supply.

3.A.2 Derivation of Conditions (3.20) and (3.29)

Derivation of condition (3.20): Cooperation entails discounted payoffs

$$\Pi^* = \sum_{t=0}^{\infty} \delta^t \pi^* = \frac{1}{1-\delta}\pi^*. \tag{3.40}$$

A defecting agenda setter receives discounted payoffs

$$\begin{aligned} \Pi^d &= \pi^a + \delta\pi^{\neg a} + \delta^2\pi^a + \delta^3\pi^{\neg a} + \ldots = \pi^a \sum_{t=0}^{\infty} \delta^{2t} + \delta\pi^{\neg a} \sum_{t=0}^{\infty} \delta^{2t} \\ &= \frac{1}{1-\delta^2}\pi^a + \frac{\delta}{1-\delta^2}\pi^{\neg a}. \end{aligned} \tag{3.41}$$

Cooperation can then be sustained if

$$\begin{aligned} \Pi^* \geq \Pi^d \quad &\Leftrightarrow \quad \frac{1}{1-\delta}\pi^* \geq \frac{1}{1-\delta^2}\pi^a + \frac{\delta}{1-\delta^2}\pi^{\neg a} \Leftrightarrow (1+\delta)\,\pi^* \geq \pi^a + \delta\pi^{\neg a} \\ &\Leftrightarrow \quad \delta\left[\pi^* - \pi^{\neg a}\right] \geq \pi^a - \pi^* \end{aligned} \tag{3.42}$$

holds.

Derivation of condition (3.29): According to (3.40), cooperation entails discounted payoffs $\Pi^* = \frac{1}{1-\delta}\pi^*$. A defecting representative rather receives discounted payoffs

$$\Pi^d = \pi^d + \sum_{t=1}^{\infty} \delta^t \pi^e = \pi^d + \frac{\delta}{1+\delta}\pi^e. \tag{3.43}$$

Cooperation can then be sustained if

$$\Pi^* \geq \Pi^d \Leftrightarrow \frac{1}{1-\delta}\pi^* \geq \pi^d + \frac{\delta}{1-\delta}\pi^e \Leftrightarrow \frac{\delta}{1-\delta}\left[\pi^* - \pi^e\right] \geq \pi^d - \pi^*.$$

3.A.3 Proof of Proposition 3

Proof. Let us first consider part (i). It is readily established that $\lim_{\phi\to 0}\delta^C = 0$ (the numerator of δ^C converges to $\ln 2$, and the denominator converges to infinity), where $\delta > 0$ holds by assumption. Turning to part (ii), observe that

$$\frac{\partial \delta^C}{\partial \phi} = \frac{\frac{1+\phi}{2}\frac{-2}{(1+\phi)^2}\ln\frac{1+\phi}{2\phi} - \frac{2\phi}{1+\phi}\frac{2\phi-2(1+\phi)}{(2\phi)^2}\ln\frac{2}{1+\phi}}{\left(\ln\frac{1+\phi}{2\phi}\right)^2} = \frac{\ln\frac{2}{1+\phi} - \phi\ln\frac{1+\phi}{2\phi}}{\phi\left(1+\phi\right)\left(\ln\frac{1+\phi}{2\phi}\right)^2} \tag{3.44}$$

which is positive if $\tilde{A} := \ln\frac{2}{1+\phi} - \phi\ln\frac{1+\phi}{2\phi} > 0$. We now establish that $\tilde{A}$ is positive for all values of ϕ. Observe that $\lim_{\phi\to 0}\tilde{A} = \ln 2 > 0$ and $\lim_{\phi\to 1}\tilde{A} = 0$. Finally,

$$\tilde{A}_\phi = \frac{1+\phi}{2}\frac{-2}{(1+\phi)^2} - \left(\ln\frac{1+\phi}{2\phi} + \phi\frac{2\phi}{1+\phi}\frac{2\phi - 2\left(1+\phi\right)}{(2\phi)^2}\right) = \ln\frac{2\phi}{1+\phi} < 0. \tag{3.45}$$

For part (iii), consider $\lim_{\phi\to 1}\delta^C$. In this case, both the numerator and the denominator converge to 0. Yet, applying de L'Hôpital's rule[56], the limit can be calculated by

$$\lim_{\phi\to 1}\frac{[\text{NUM }\left(\delta^C\right)]'}{[\text{DEN }\left(\delta^C\right)]'} = \lim_{\phi\to 1}\frac{-\frac{1}{1+\phi}}{-\frac{1}{\phi(1+\phi)}} = \lim_{\phi\to 1}\phi = 1, \tag{3.46}$$

where $\delta < 1$ holds by assumption. ■

[56] See, e.g. Chiang (1984), pp. 429, for an introduction to de L'Hôpital's rule.

3.A.4 Proof of Proposition 4

Proof. Note that

$$\frac{\partial \delta^D}{\partial \phi} = \frac{\left(1 - \frac{1}{1+\phi}\right)\frac{\phi^2}{1+\phi} - \left[\phi - \ln\left(1+\phi\right)\right]\frac{2\phi(1+\phi)-\phi^2}{(1+\phi)^2}}{\left(\frac{\phi^2}{1+\phi}\right)^2} = \frac{\ln\left(1+\phi\right) - \frac{2\phi}{2+\phi}}{\frac{\phi^3}{2+\phi}} \tag{3.47}$$

which is positive if $\tilde{B} := \ln\left(1+\phi\right) - \frac{2\phi}{2+\phi} > 0$. We now establish that $\tilde{B}$ is positive for all values of ϕ. To this end, note that $\lim_{\phi\to 0}\tilde{B} = 0$ and $\lim_{\phi\to 1}\tilde{B} = \ln 2 - \frac{2}{3} > 0$. Finally,

$$\tilde{B}_\phi = \frac{1}{1+\phi} - \frac{2\left(2+\phi\right) - 2\phi}{\left(2+\phi\right)^2} = \frac{\phi^2}{\left(1+\phi\right)\left(2+\phi\right)^2} > 0. \tag{3.48}$$

■

Turning to the limit values, consider $\lim_{\phi\to 0}\delta^D$. In this case, both the numerator and the denominator of δ^D converge to 0. Yet, applying de L'Hôpital's rule, the limit can be calculated by

$$\lim_{\phi\to 0}\frac{[\text{NUM }\left(\delta^D\right)]'}{[\text{DEN }\left(\delta^D\right)]'} = \lim_{\phi\to 0}\frac{\frac{\phi}{1+\phi}}{\frac{\phi(2+\phi)}{(1+\phi)^2}} = \lim_{\phi\to 0}\frac{1+\phi}{2+\phi} = \frac{1}{2}. \tag{3.49}$$

It is readily established that $\lim_{\phi\to 1}\delta^D = 2\left(1 - \ln 2\right)$ as the numerator converges to $1 - \ln 2$ whereas the denominator converges to $\frac{1}{2}$.

4. Interregional Heterogeneity

4.1 Introduction Chapter 4

The Oates approach is, certainly, most famous for its decentralization theorem. Yet, Oates' results, as laid out in proposition 1, furthermore assign public good policies contingent on interregional heterogeneity. Recall that the central (decentral) layer fails to account for interregional preference heterogeneity (spillovers). In the polar case of pure local public goods, there are no externalities and thus no drawback from decentralization. Hence, no-spillover policies should be assigned to a decentralized regime. Yet, Oates' results establish a positive correlation between heterogeneity and the optimal degree of decentralization.[57]

Whereas the decentralization theorem is widely accepted as a thorough argument against centralizing public services, the Oates model yields a less noted – and possibly less intended – vice versa result when it comes to assigning pure public good policies. The respective guideline might be dubbed 'centralization theorem' as, following the Oates logic, "*the administration of nonexcludable goods should be centralized*".[58] The intuitive reason behind this result is that whenever there is inherent uniformity of consumption, accounting for regional tastes on the basis of average regional preferences is *first best* (see e.g. Samuelson (1954)). Hence, restricting the benevolent central decision maker to uniform policies does not lead to any inefficiencies whereas decentralization's free-riding externality still emerges.

[57]Panizza (1999) measures heterogeneity by the degree of ethnic fractionalization. In his empirical analysis, he finds a negative correlation between heterogeneity and the degree of fiscal centralization.
[58]Casella and Frey (1992), p. 643.

Yet, the Oates approach has been criticized for neglecting political economy considerations. On behalf of the respective literature, Inman and Rubinfeld (1997) argue that a specific shortcoming of the Oates approach "*has been to advocate the central government as the only institution best able to provide pure public goods*" (pp. 47-48) whereas one should rather "*explicitly recognize the potential failings of central government policy-making*" (p. 48). In this line of critique, Ellingsen (1998) builds on a political economy based pure public goods model and refutes the above Oates result. He rather shows that decentralization has its normative virtues for large interregional heterogeneity.

The purpose for the present chapter is to scrutinize the 'centralization theorem' in a repeated game setting. Following the static/repeated game structure presented in chapter 3, centralized (decentralized) public good provision results from an agenda (a voluntary provision) game played among regional representatives. We introduce interregional preference heterogeneity in a pure public goods framework and find that efficient public good policies can neither be sustained under a centralized nor decentralized regime in case of substantial heterogeneity. Whereas the high-preference region can credibly commit to cooperation under both regimes, the low-preference region can neither resist the temptation to abuse agenda power in a federal legislature nor oppose the temptation to free-ride in the decentralized setting. Hence, cooperation necessarily breaks down for substantial heterogeneity. In other words, substantial preference heterogeneity renders the stage game perspective relevant. As our stage game perspective basically entails the same implications as Ellingsen (1998), we support his rejection of the 'centralization theorem' from a repeated game perspective.

The remainder of this chapter is organized as follows. Section 4.2 presents the basic heterogeneity framework and derives the benchmark of efficient public good provision. Section 4.3 introduces the centralized and decentralized setting and analyzes the relative merits with respect to heterogeneity in a static setting. Like in chapter 3, regional representatives play an agenda game and a voluntary provision game under the centralized and decentralized regime, respectively. Section 4.4 extends both one-shot games to an infinite horizon and analyzes the respective conditions for maintaining cooperation. Section 4.5 concludes.

4.2 Economic Environment

Throughout this chapter, the economy is divided into two distinct regions indexed by $i \in \{1,2\}$. Immobile regional populations are normalized to 1, respectively. The preferences for an individual in region i are represented by utility

$$U_i\left(G, x_i\right)=\left\{\begin{array}{cc}\beta \ln G+x_i & i=1 \\ (1-\sigma) \beta \ln G+x_i & i=2\end{array}\right. . \tag{4.1}$$

We assume $0<\beta$ and $0<\sigma<1$, i.e. public good demand is always positive and higher in region 1. We shall, therefore, label region 1 (2) the high- (low-) preference region. The parameter σ measures the degree of heterogeneity among regional public good preferences. For values of σ close to 1 (0), there is large preference disparity (similarity). Prices for the pure public good G and the private good x are set to p and 1, respectively. Again, residents are endowed with sufficient income ω to allow for positive private good consumption.

4.2.1 Efficiency Benchmark

As the utility in (4.1) represents quasi-linear preferences, the maximization of aggregate public good surplus is, once more, equivalent to a Paretian analysis. Hence, the efficient allocation calls to choose the level of G in a way to maximize the overall public good surplus

$$S^{+}=(2-\sigma) \beta \ln G-p G. \tag{4.2}$$

Differentiate (4.2) with respect to G to obtain a standard *Samuelson-condition*

$$\frac{(2-\sigma)\,\beta}{G^*} = p. \tag{4.3}$$

Condition (4.3) implies to choose the level of public goods that equates the aggregate marginal willingness to pay for the public good and the marginal costs of public good provision. This Samuelson-condition entails the efficient quantity

$$G^* = \frac{(2-\sigma)\,\beta}{p}. \tag{4.4}$$

Note that the aggregate marginal willingness to pay for the public good is essentially measured by the average regional public good preference. Whereas providing uniform public good provision according to the average regional preference turns out to harm efficiency in a setting with local public goods (see chapter 2), there are no such efficiency losses in a pure public goods setting. As was argued before, the intuitive reason is that whenever there is inherent uniformity of consumption, as is the case for pure public goods, there is no need for the optimal allocation to differentiate regional quantities. As regional preferences merely pertain to the overall provision level, an allocation according to the overall average of preferences is efficient.[59]

Having derived the benchmark solution, the next section analyzes the static perspective of policy-making. We shall start with the decentralized regime of public good provision.

[59] Decomposing the aggregate marginal willingness to pay for the public good, condition (4.3) can be expressed as $2\frac{\frac{1}{2}(1+1-\sigma)}{G^*}\beta = p$. The latter representation stresses the fact that the optimal allocation of pure public goods accounts for the average regional public good preference (see the discussion of Oates' results for pure public goods in section 4.1).

4.3 Static Heterogeneity Setting

4.3.1 Decentralized Regime

In the decentralized setting, regional representatives play a non-cooperative voluntary contribution game, i.e. a representative divides the endowment ω between private consumption and the regional contribution g_i to the pure public good. The total amount of the public good then reads as $G = g_1 + g_2$. Accordingly, the regional public good surplus under the decentralized regime is represented by

$$S_{iD} = \begin{cases} \beta \ln G - p g_1 & i = 1 \\ (1-\sigma)\,\beta \ln G - p g_2 & i = 2 \end{cases} . \tag{4.5}$$

As both representatives are assumed to choose their contributions simultaneously, the stage game Nash-equilibrium of the decentralized contribution game is characterized by

$$g_i^e = \arg\max_{g_i \geq 0}\; S_{iD}\left(g_i, g_{-i}^e\right). \tag{4.6}$$

If both regions were to make positive contributions, the corresponding quantities were to satisfy the first-order conditions and reaction functions

$$\begin{aligned} \frac{\beta}{g_1 + g_2} &= p \Leftrightarrow g_1 = \frac{\beta}{p} - g_2 \\ \frac{(1-\sigma)\,\beta}{g_1 + g_2} &= p \Leftrightarrow g_2 = \frac{(1-\sigma)\,\beta}{p} - g_1 \end{aligned} \tag{4.7}$$

for the high-preference and the low-preference region, respectively. In equilibrium, though, only one of the conditions in (4.7) holds as a strict equality. As Varian (1994),

pp. 167, shows for a two-agent simultaneous-move game with quasi-linear utility, only the individual with the higher marginal willingness to pay will contribute whereas the other individual free-rides completely.[60] The intuition for this result is that, given the stand-alone contribution by the individual with the higher preference, the other individual's marginal willingness to pay for an additional unit of the public good is lower than its respective marginal costs.
We can immediately apply the above logic. In our setting, the stand-alone (zero) contribution by the region with the higher (lower) aggregate preference are mutually best responses.[61]

Figure 4.1 illustrates the reaction functions (4.7) for region 1 (solid line) and region 2 (dashed line), as well as the Nash-equilibrium.

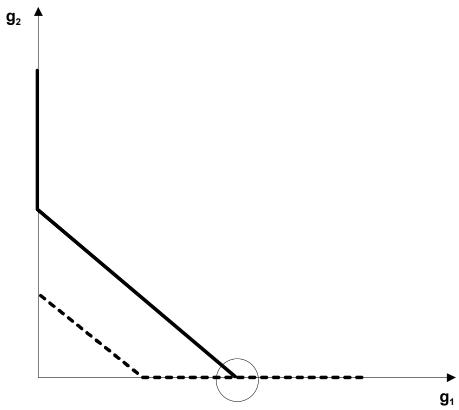


Figure 4.1: Reaction curves and Nash-equilibrium for the voluntary contribution game (adapted from Varian (1994), p. 167)

According to figure 4.1, region i responds to a one-unit increase of g_{-i} by decreasing

[60] Bergstrom et al. (1986), pp. 32., provide the formal proof of uniqueness and existence of Nash-equilibria in voluntary contribution games for a general class of utility.

[61] In our model, both regions contain an equal share of residents. Our result is, therefore, a special case of the results derived in Ellingsen (1998), pp. 256-257. He extends the Varian (1994) result to a setting with interregional preference *and* population disparity and shows that only the region with the higher aggregate marginal willingness to pay for the public good will contribute at all.

g_i by the same amount (the reaction curves are sloped by -1 and thus run parallel in $\mathbb{R}^2_+$), i.e.regional contributions are strategic substitutes. The Nash-equilibrium is characterized by the intersection of both reaction functions, as marked by the circle. It is readily checked that the high-preference region 1 is the stand-alone contributor whereas the low-preference region 2 contributes nothing. The reaction functions in (4.7) imply that the equilibrium public good provision in the decentral stage game is characterized by contributions

$$\{g_1^e = G^e, g_2^e\} = \left\{\frac{\beta}{p}, 0\right\}, \tag{4.8}$$

where G^e denotes the aggregate public good quantity in the stage game equilibrium. A comparison of (4.8) and (4.4) reveals the well-known feature of underprovision in the decentral stage game equilibrium. Furthermore, the degree of underprovision $G^* - G^e$ decreases in σ. Intuitively, the free-riding problem in terms of lost public good surplus is worst for similar preferences and least if the free-riding region has a low preference relative to the contributing region.

For reference purposes in subsection 4.3.3, insert (4.8) into (4.2) to obtain the public good surplus under a decentralized regime

$$S_D^+ = S^+(G^e) = (2-\sigma)\,\beta \ln \frac{\beta}{p} - \beta. \tag{4.9}$$

Let us now turn to the centralized regime.

4.3.2 Centralized Regime

The centralized regime is basically adapted from the static agenda model, as introduced in subsection 3.3.1. As there is preference asymmetry, representatives are likely to induce asymmetric stage game equilibrium policies. This is due to the fact that the aggregate public good quantity and, therefore, the aggregate public good surplus depend on who is actually assigned agenda power. At this point, the random assignment of agenda power is helpful as it allows us to carry out the subsequent regime ranking on a basis of average overall surplus.

Following the model in subsection 3.3.1, centralized public good provision is financed via standard head taxes

$$\tau_{iC} = \frac{p}{2}G. \tag{4.10}$$

Accordingly, the region-specific public good surplus under a centralized regime can be expressed as

$$S_{iC} = \begin{cases} \beta \ln G - \frac{p}{2}G & i = 1 \\ (1-\sigma)\,\beta \ln G - \frac{p}{2}G & i = 2 \end{cases}. \tag{4.11}$$

Again, the status quo policy entails no public good provision at all. Given the utility-function in (4.1), this fact implies that, once agenda power has been assigned, an agenda setter from region i can propose a level of G that maximizes her region's surplus in (4.11). Hence, the corresponding stage game equilibrium levels of G read as

$$\{G_1^a, G_2^a\} = \left\{\frac{2\beta}{p}, \frac{2\,(1-\sigma)\,\beta}{p}\right\}. \tag{4.12}$$

Inserting these quantities into (4.2) and recalling the random allocation of agenda power, the average surplus S_C^+ under a regime of centralized public good provision can be expressed as

$$S_C^+ = \frac{S^+\,(G_1^a) + S^+\,(G_2^a)}{2} = (2-\sigma)\,\beta\left[\ln\frac{2\sqrt{1-\sigma}\beta}{p} - 1\right]. \tag{4.13}$$

We shall now carry out the regime ranking for the static setting.

4.3.3 Regime Ranking in the Static Heterogeneity Setting

For the regime ranking, we shall compare the aggregate public good surplus under a centralized regime S_C^+ to the aggregate public good surplus under a decentralized regime S_D^+. For which degrees of preference heterogeneity should a specific regime then be assigned the right to exercise public goods policies?

Proposition 6 *In the static setting, there exists a critical level of heterogeneity $\hat{\sigma}$ in a way that a centralized (decentralized) regime is surplus-superior for heterogeneity levels lesser (greater) than $\hat{\sigma}$.*

Proof. Subtracting (4.9) from (4.13), the surplus gap can be expressed as

$$S_C^+ - S_D^+ = \beta \left[\frac{2-\sigma}{2} \ln 4 (1-\sigma) - (1-\sigma) \right]. \tag{4.14}$$

Observe that (4.14) converges to $\beta (\ln 4 - 1)$ for $\sigma \to 0$ and to $-\infty$ for $\sigma \to 1$. Hence, the surplus gap is positive for low heterogeneity and negative for high heterogeneity. Next, define $\hat{\sigma}$ so that $S_C^+ (\hat{\sigma}) = S_D^+ (\hat{\sigma})$. Finally, differentiate (4.14) with respect to σ to obtain $\frac{\partial \left(S_C^+ - S_D^+ \right)}{\partial \sigma} = -\frac{\beta}{2} \left[\ln 4 (1-\sigma) + \frac{\sigma}{1-\sigma} \right]$ which is strictly negative because of $\lim\limits_{\sigma \to 0} \frac{\partial \left(S_C^+ - S_D^+ \right)}{\partial \sigma} = -\beta \ln 2 < 0$ and $\frac{\partial^2 \left(S_C^+ - S_D^+ \right)}{\partial \sigma^2} = -\frac{\beta \sigma}{2(1-\sigma)^2} < 0$. ■

Similar to section 3.3, there are fundamental and regime-specific inefficiencies driving the results in proposition 6. Centralization induces a distortion because the agenda equilibrium merely reflects the agenda setter's preference for the public good. The respective distortion in terms of deviation from the efficient allocation is obviously zero for identical regional tastes. Vice versa, the efficiency loss turns out increasingly severe as heterogeneity increases.

On the other hand, the decentralized regime suffers from free-riding by the low-preference region. The efficiency losses associated with the respective underprovision are utmost severe for small heterogeneity. In this case, the decentral equilibrium does not account for a relatively large additional preference for the public good. By an analogous argument, the externality decreases in heterogeneity and vanishes in the limiting case of maximum heterogeneity.

Figure 4.2 illustrates the results in proposition 6 by depicting (4.14) for $\beta = 1$.

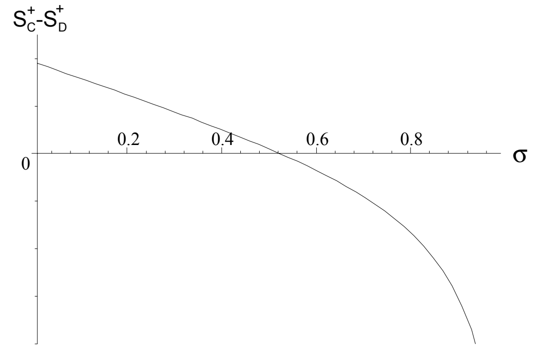


Figure 4.2: Surplus gap in the static heterogeneity setting

Bringing together the two types of inefficiencies, our static setting challenges the 'centralization theorem' à la Oates. In particular, the central layer should *not* be assigned the right to execute pure public good policies if there is substantial interregional preference heterogeneity. Recall, though, that the results in the spillover setting of chapter 3 were reversed in the transition from the static to the dynamic perspective. The following section, therefore, scrutinizes the 'centralization theorem' in a repeated game setting.

4.4 The Repeated Heterogeneity Setting

In the repeated setting, representatives play the respective stage games, as described in subsections 4.3.1 and 4.3.2, over an infinite horizon. As in section 3.4, representatives have a common discount factor $0 < \delta < 1$, and there is perfect recall with regard to the game's history. Again, binding contracts are not possible.

4.4.1 The Dynamics of Decentralization

Due to the asymmetry of stage game payoffs, the efficient contribution scheme for the decentralized setting requires some elaboration. Let us first of all review the free-riding problem that emerges in the static perspective. Figure 4.3 illustrates the marginal willingness to pay for the public good in the low-preference region (lower solid line), the high-preference region (upper solid line), the aggregate demand (dashed line), and the marginal costs of public good provision (dotted line) for $\sigma = 0.5$ and $\beta = p = 1$.

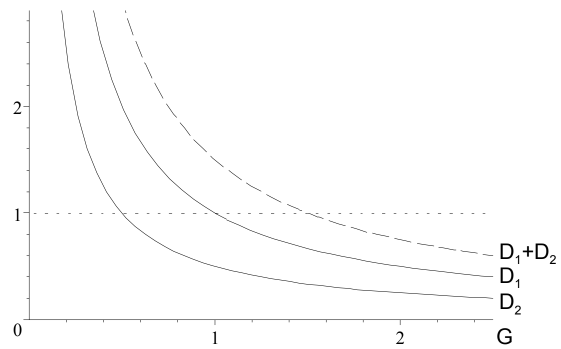


Figure 4.3: Regional and aggregate demand for the public good

In the stage game equilibrium, the high-preference region provides $G^e = 1$ whereas the surplus-maximizing provision amounts to $G^* = 1.5$. Hence, there is some additional aggregate surplus at stake that might be absorbed by the regions. In figure 4.3, this surplus amounts to the area that is bordered by the aggregate demand curve, the marginal cost curve, the equilibrium public good quantity, and the efficient quantity. Yet, given the stand-alone contribution by the high-preference region, the low-preference region has no incentive to exercise any additional contributio as it faces additional costs of 1 whereas its willingness to pay for an additional public good quantity merely amounts to 0.5. On the other hand, the high-preference region is, obviously, not willing to bear the complete costs for extending the provision.

Building on these considerations, the problem of sustaining efficient policies in the repeated decentralized game can be described as follows. Find a contribution scheme $\{g_1^*, g_2^*\}$ that (i) eliminates the underprovision $G^* - G^e$, (ii) leaves both regions better off compared to the stage game equilibrium, and (iii) is self-enforcing in a sense that all parties adhere to cooperation on a voluntary basis. Obviously, there are many ways to meet (i) and (ii) simultaneously. There may even be solutions that allocate the whole additional surplus to just one region. Yet, such a polar split is likely to imply the violation of (iii) for the region that is passed over as there is no gain from cooperation for this region.[62]

An intuitive way to meet (i) and (ii) for both regions is to agree on providing $G^* - G^e$ according to a Lindahl-like scheme, i.e. a region contributes to the provision gap according to its willingness to pay for the additional public good quantity.[63] Accordingly, region 1 provides G^e and, furthermore, incurs a fraction $\frac{1}{2-\sigma}$ of the provision gap whereas region 2 bears a share $\frac{1-\sigma}{2-\sigma}$ of the additional quantity. Contrasting the results in the symmetric setting of chapter 3, cooperation now necessarily entails different regional tax burdens as the region that free-rides in the stage game equilibrium would never agree to an equal share of overall costs pG^*. The optimal Lindahl-like

[62] If binding contracts were possible, the regions were able to ignore the restriction in (iii) and actually stipulate any split of the additional surplus. Yet, as we are interested in self-enforcing solutions, we explicitly recognize (iii).

[63] Lindahl (1919) discussed the possibility of decentralizing an optimal provision of public goods. His basic idea was to assign financing shares according to the willingness to pay for the public good. Cullis and Jones (1998), pp. 55-57, present a comprehensive analysis of the genuine Lindahl solution.

contribution scheme reads as

$$\begin{aligned}\{g_1^*, g_2^*\} &= \left\{G^e + \frac{1}{2-\sigma}\left(G^* - G^e\right), \frac{1-\sigma}{2-\sigma}\left(G^* - G^e\right)\right\} \\ &= \left\{\frac{3-2\sigma}{2-\sigma}\frac{\beta}{p}, \frac{(1-\sigma)^2}{2-\sigma}\frac{\beta}{p}\right\}.\end{aligned} \tag{4.15}$$

If both representatives adhere to the above contribution scheme, the respective periodical payoffs can be expressed as

$$\begin{aligned}\{\pi_1^*, \pi_2^*\} &= \left\{S_{1D}\left(g_1^*, g_2^*\right), S_{2D}\left(g_1^*, g_2^*\right)\right\} \\ &= \left\{\beta \ln \frac{(2-\sigma)\beta}{p} - \frac{(3-2\sigma)\beta}{2-\sigma}, (1-\sigma)\beta \ln \frac{(2-\sigma)\beta}{p} - \frac{(1-\sigma)^2\beta}{2-\sigma}\right\}.\end{aligned} \tag{4.16}$$

Turning to requirement (iii), suppose that both representatives employ trigger-strategies

$$g_i = \begin{cases} g_i^* & \text{if } t = 1 \\ g_i^* & \text{if } t > 1 \ \wedge \ h_t = \left\{\left(g_1^*, g_2^*\right)_1, \ldots, \left(g_1^*, g_2^*\right)_{t-1}\right\} \\ g_i^e & \text{else} \end{cases} \tag{4.17}$$

in order to overcome the mutual short-run incentives to deviate from the cooperative contribution scheme in (4.15). When do the strategies in (4.17) yield self-enforcing cooperation? Consider a representative that chooses to defect from (4.15). Her optimal contribution g_i^d is characterized by

$$g_i^d = \arg\max_{g_i \geq 0} \ S_{iD}\left(g_i, g_{-i}^*\right). \tag{4.18}$$

Due to the interregional preference heterogeneity, these quantities are certainly not symmetric. A representative from region 2 anticipates g_1^*, and chooses to fully withdraw her contribution. As contributing nothing is already her best response to g_1^e, it is also her best response to $g_1^* > g_1^e$. On the other hand, a defecting representative from region 1 anticipates $g_2^* < g_1^e$ but rather prefers a larger quantity of public goods. Recalling figure 4.1, she chooses g_1^d in a way to close the gap $g_1^e - g_2^*$. Accordingly, the respective quantities under unilateral defection read as

$$\left\{g_1^d, g_2^d\right\} = \left\{\frac{1+\sigma-\sigma^2}{2-\sigma}\frac{\beta}{p}, 0\right\}. \tag{4.19}$$

Inserting (4.19) and (4.15) into (4.5), a representative reaps payoffs

$$\begin{aligned} \left\{\pi_1^d, \pi_2^d\right\} &= \left\{S_{1D}\left(g_1^d, g_2^*\right), S_{2D}\left(g_1^*, g_2^d\right)\right\} \\ &= \left\{\beta \ln \frac{\beta}{p} - \frac{1+\sigma-\sigma^2}{2-\sigma}\beta, (1-\sigma)\,\beta \ln \frac{3-2\sigma}{2-\sigma}\frac{\beta}{p}\right\} \end{aligned} \tag{4.20}$$

in the period of defection. Yet, she induces infinite Nash-reversion, and representatives earn stage game equilibrium payoffs

$$\begin{aligned} \left\{\pi_1^e, \pi_2^e\right\} &= \left\{S_{1D}\left(g_1^e, g_2^e\right), S_{2D}\left(g_1^e, g_2^e\right)\right\} \\ &= \left\{\beta \ln \frac{\beta}{p} - \beta, (1-\sigma)\,\beta \ln \frac{\beta}{p}\right\} \end{aligned} \tag{4.21}$$

in all subsequent periods.

How can cooperation be sustained under the decentralized regime? Building on the analysis of the voluntary provision game in subsection (3.4.2), we now obtain region-specific critical discounting parameters. Insert (4.16), (4.20), and (4.21) into (3.30), and simplify the resulting expression to obtain

$$\left\{\delta_1^D, \delta_2^D\right\} = \left\{\frac{\ln\frac{1}{2-\sigma} + 1 - \sigma}{\frac{(1-\sigma)^2}{2-\sigma}}, \frac{\ln\frac{3-2\sigma}{(2-\sigma)^2} + \frac{1-\sigma}{2-\sigma}}{\ln\frac{3-2\sigma}{2-\sigma}}\right\}. \tag{4.22}$$

Again, cooperation can be maintained if the necessary condition for maintaining cooperation is satisfied for both representatives. As the critical discounting parameters are now region-specific, cooperation can be maintained if $\delta \geq \max\left\{\delta_1^D, \delta_2^D\right\}$ holds.

What does (4.22) say about cooperation in the decentralized setting?

Proposition 7 *In the decentralized setting, cooperation cannot be sustained for sufficient preference heterogeneity.*

Proof. Proposition 7 requires that, for sufficient preference heterogeneity, at least one representative will defect from cooperation. Considering $\lim_{\sigma\to 1}\delta_2^D$, both the numerator and the denominator converge to 0. Yet, applying de L'Hôpital's rule, the limit can be calculated by $\lim_{\sigma\to 1}\frac{[\text{NUM}\left(\delta_2^D\right)]'}{[\text{DEN}\left(\delta_2^D\right)]'} = \lim_{\sigma\to 1}\frac{\frac{2(1-\sigma)}{(3-2\sigma)(2-\sigma)} - \frac{1}{(2-\sigma)^2}}{-\frac{1}{2-\sigma}} = 1$, where $\delta < 1$ holds by assumption. ■

Accordingly, the representative from the low-preference region cannot commit to cooperation. Interestingly, the representative from the high-preference region can always commit to cooperation (observe that $\lim_{\sigma\to 1}\delta_1^D = 0$).

What leads to this result? For the representative from the low-preference region, the gain from defection, as measured by $\pi_2^d - \pi_2^*$, decreases in heterogeneity. This is due to the fact that the cooperative contribution scheme accounts for an increased degree of heterogeneity by decreasing the tax burden for the low-preference region. In the limiting case, the cooperative contribution scheme demands no contribution at all from the low-preference region. On the other hand, the costs of defection, $\pi_2^* - \pi_2^e$, likewise decrease for the low-preference region. This is due to the fact that the degree of underprovision decreases in heterogeneity and disappears in the limiting case of maximum heterogeneity. This latter effect mitigates the consequences of free-riding, and thus proves welfare-enhancing in the static setting (see proposition 6). In the repeated setting it rather hampers efficiency. In the limit, there are virtually no costs from defection for the low-preference region, and cooperation cannot be sustained.

Let us now analyze whether there are admissible values of the discount parameter in a way that cooperation among heterogeneous regions can be sustained under the centralized regime.

4.4.2 The Dynamics of Centralization

For the repeated game of centralized decision-making, we build on the model introduced in subsection (3.4.1), i.e. agenda power rotates among representatives, and the latter employ trigger-strategies in order to maintain cooperative outcomes. For a representative from region i, these trigger-strategies now read as

$$\begin{array}{ll} \text{propose } G^* & \text{if } i = a \ \wedge \ t = 1 \\ \text{propose } G^* & \text{if } i = a \ \wedge \ t > 1 \ \wedge \ h_t = \left(\{G^*\}_1, \ldots, \{G^*\}_{t-1}\right) \\ \text{propose } G_i^a & \text{if } i = a \ \wedge \ t > 1 \ \wedge \ h_t \neq \left(\{G^*\}_1, \ldots, \{G^*\}_{t-1}\right) \\ \text{accept proposal} & \text{if } S_{iC}^{PR} \geq S_{iC}^{SQ} \end{array} . \tag{4.23}$$

Again, the superscripts PR and SQ represent the proposal and the status quo, respectively. Under a cooperative legislature, agenda setters perpetually propose the efficient public good quantity G^*. As, contrasting the setting in chapter 3, both representatives now value public goods differently, the corresponding cooperative payoffs are no longer symmetric but rather read as

$$\begin{aligned} \{\pi_1^*, \pi_2^*\} &= \{S_{1C}(G^*), S_{2C}(G^*)\} \\ &= \left\{\beta \ln \frac{(2-\sigma)\beta}{p} - \frac{(2-\sigma)\beta}{2}, (1-\sigma)\beta \ln \frac{(2-\sigma)\beta}{p} - \frac{(2-\sigma)\beta}{2}\right\}. \end{aligned} \tag{4.24}$$

In case of a defection, there is infinite Nash-reversion, and agenda setters propose the respective stage equilibrium quantities (4.12) in all subsequent periods. Inserting (4.12) into (4.11), the payoffs for the representative from region i read as

$$\begin{aligned} \{\pi_1^a, \pi_2^a\} &= \{S_{1C}(G_1^a), S_{2C}(G_2^a)\} \\ &= \left\{\beta \ln \frac{2\beta}{p} - \beta, (1-\sigma)\beta \ln \frac{2(1-\sigma)\beta}{p} - (1-\sigma)\beta\right\} \end{aligned} \tag{4.25}$$

in periods she holds and abuses agenda power. On the other hand, she receives

$$\begin{aligned} \{\pi_1^{\neg a}, \pi_2^{\neg a}\} &= \{S_{1C}(G_2^a), S_{2C}(G_1^a)\} \\ &= \left\{\beta \ln \frac{2(1-\sigma)\beta}{p} - (1-\sigma)\beta, (1-\sigma)\beta \ln \frac{2\beta}{p} - \beta\right\} \end{aligned} \tag{4.26}$$

in case she is exposed to agenda power. When can cooperation be maintained in the centralized setting?

Just like in subsection 3.4.1, the individual payoffs are ranked by $\pi_i^a > \pi_i^* > \pi_i^{\neg a}$. As both repeated agenda games, furthermore, exhibit the same general structure, we can refer to the general necessary condition for maintaining cooperation under a centralized regime (3.20) and, in particular, to the general critical discounting parameter, as presented in (3.21). Due to the fact that heterogeneity induces a payoff asymmetry, we now obtain region-specific critical discounting parameters. Inserting (4.24), (4.25), and (4.26) into (3.21) and simplifying the resulting expressions, the latter can be expressed as

$$\left\{\delta_1^C, \delta_2^C\right\} = \left\{\frac{\ln\frac{2}{2-\sigma} - \frac{\sigma}{2}}{\ln\frac{2-\sigma}{2(1-\sigma)} - \frac{\sigma}{2}}, \frac{(1-\sigma)\ln\frac{2-2\sigma}{2-\sigma} + \frac{\sigma}{2}}{(1-\sigma)\ln\frac{2-\sigma}{2} + \frac{\sigma}{2}}\right\}. \tag{4.27}$$

Again, cooperation can be maintained if the necessary condition for maintaining cooperation is satisfied for both representatives. As the critical discounting parameters are now region-specific, cooperation can be maintained if $\delta \geq \max\left\{\delta_1^C, \delta_2^C\right\}$ holds.

What can we now say about efficiency-sustaining cooperation and heterogeneity? We have the following proposition.[64]

Proposition 8 *In the centralized setting, cooperation cannot be sustained for sufficiently large heterogeneity.*

Proof. Proposition 8 requires that, for sufficient preference heterogeneity, at least one representative will choose to defect from cooperation. Observe that $\lim_{\sigma\to 1}\delta_2^C = 1$ ($1-\sigma$ dominates the respective logarithmic terms in the limit), where $\delta < 1$ holds by assumption. ■

In other words, there are no admissible values of the discounting parameter so that cooperation is self-enforcing for the representative from the low-preference region. Again, the representative from the high-preference region can always commit to cooperation (observe that $\lim_{\sigma\to 1}\delta_1^C = 0$).

What drives the above results? Let us start with the high-preference representative. Her favored agenda quantity does not depend on the degree of heterogeneity. At the same time, even for utmost heterogenous preferences, the cooperative solution

[64] Proposition 8 likewise emerges, if agenda power is assigned randomly with equal probability at the beginning of *each* stage game.

still accounts for the positive preference of the high-preference region and, therefore, induces a positive public good quantity. The high-preference representative, therefore, obtains a finite gain from defection, $\pi_1^a - \pi_1^*$. On the other hand, she suffers duly from the narrow agenda quantity implemented by the low-preference representative whereas she merely perceives the cooperative quantity as 'too low'. In the limit, she rather faces infinite costs of defection, $\pi_1^* - \pi_1^{\neg a}$, i.e. the high-preference representative is then willing to succumb to cooperation.

This result can be attributed to the concept of consumption smoothing, as mentioned in chapter 3. Under an uncooperative legislature, large preference heterogeneity induces a large dispersion of public good quantities that is particularly unpleasant for the high-preference representative. As the average level of public goods in the agenda equilibrium equals the cooperative level of public goods, her preference for consumption smoothing over time particularly fosters her adherence to cooperation in the case of substantial heterogeneity.

Vice versa, the low-preference representative completely lacks any preference for the public good in the limiting case of large preference heterogeneity.[65] Disregarding the fact that she actually does not receive any benefits from public good provision, she is due to contribute means. As she prefers zero provision, she evaluates her strategies according to the mere costs associated with public good provision.
Following this argument, recall that the average level of public goods in the agenda equilibrium equals the cooperative level of public goods. Compared to cooperation, the contribution she saves by using agenda power, therefore, exactly corresponds to the additional means she is due to contribute in case she is exposed to agenda power. Consequently, she prefers to put the gains from defection first, irrespective of her degree of impatience.

Let us compare the results in propositions 7 and 8. Which regime should be assigned

[65] The same is true for her preference for consumption smoothing over time.

the right to execute pure public good policies in the case of substantial interregional preference heterogeneity? At first glance, there seems to be no clear-cut answer to this question as both regimes fail to sustain the efficient public good quantities. Yet, the latter fact implies that the stage game policies are due to emerge for high preference heterogeneity. Building on the results in proposition 6, we can, therefore, conclude that pure public good provision should be assigned to the decentral layer in case of substantial heterogeneity. Although both regimes fail to yield efficient outcomes, the consequences of falling back to the stage game equilibrium are much less severe under the decentral regime.

4.5 Conclusion Chapter 4

This chapter has addressed the question whether a centralized or a decentralized regime should be assigned the right to exercise pure public good policies if there is substantial preference heterogeneity among regions. Recent contributions to the literature of fiscal federalism (e.g. Inman and Rubinfeld (1997)) have criticized the Oates 'centralization theorem', i.e. the call for general assignment of pure public good policies to the central layer, for leaving out political economy considerations. We capture this critique by extending the basic models of centralized and decentralized decision-making, as introduced in chapter 3, to a framework with pure public goods and interregional preference heterogeneity.

Our static results show that the decentralized regime has its virtues for large heterogeneity as the distortion from free-riding is then less severe than the distortion from policy variance under the centralized regime. In the repeated game perspective, we analyzed whether a centralized or a decentralized regime is more likely to yield efficient outcomes. Our results are driven by the effect of heterogeneity on the payoffs π^a, $\pi^{\neg a}$, and π^* in the centralized setting and on the payoffs π^*, π^d, and π^e in the decentralized setting. We find that efficient public good policies are neither sustainable under the centralized nor under the decentralized regime. This result stems from the fact that the low-preference region can neither resist the temptation to overemphasize its preference by exploiting political power in a federal legislature nor resist the temptation to free-ride in the decentralized setting. Falling back to the stage game equilibria, the case for decentralization, therefore, arises for substantial heterogeneity. Hence, we extend the critique of the 'centralization theorem' to a repeated game setting.

Of course, we do not find general results as we restrict the analysis to specific taxation schemes. In particular, the results for the decentralized setting are valid only for the Lindahl-like taxation scheme. Whereas the resulting cooperative contribution scheme is certainly cogent, proposition 7 does not imply that there exists *no* cost-sharing arrangement that enables cooperation for large heterogeneity and sufficiently patient representatives. Yet, all we say is that the decentralized regime is preferred for substantial heterogeneity. This claim is even more viable in case there exist cost sharing arrangements in a way that cooperation can be sustained under the decentral regime.

5. Enlargements

5.1 Introduction Chapter 5

The two previous chapters introduced a dynamic perspective of centralized and decentralized public good provision. We have, hitherto, analyzed the impact of spillovers and heterogeneity on the regime-specific ability to yield efficient public good policies in a setting with 2 regions. The purpose for this chapter is to extend such an analysis to the case of multiple regions. In particular, we are interested in analyzing the effect enlargements induce on the ability to maintain cooperation.

Our analysis is in a way complimentary to a contribution by Pecorino (1999). He analyzes the impact of group size on the ability to sustain efficiency in a decentralized repeated game of voluntary contribution to a pure public good. Yet, we interpret his model in a way that regional governments aim at overcoming the well-known underprovision problem. Unfortunately, Pecorino (1999) does not find a clear-cut correlation between the size of a group/federation and the ability to yield efficient outcomes. Specifically, his critical discounting parameters do not vary monotonically in the number of individuals/regions. Yet, his central results show that cooperation does not necessarily break down in a 'decentralized setting' if the number of individuals/regions increases. In particular, as the critical discounting parameter converges to some value strictly smaller than unity, there are admissible values of δ in a way that cooperation can be maintained in the limit. Complementary to Pecorino's analysis, the basic puzzle for this chapter is whether or not efficient public good policies are harder to sustain in federal legislatures if the number of federal member states increases.

In the context of legislature enlargements, a large branch of the literature concludes that large legislatures tend to lack mechanisms for efficient decision-making. Heterogeneity among representatives may induce substantial costs of policy implementation in large legislatures, e.g. due to protracted negotiations.[66] Yet, as 'agreement costs' are a well-understood source for legislative inefficiencies, our framework for centralized policy-making, as introduced in subsection 3.3.1, abstracts from the former by employing closed-rule voting procedures.

As Weingast (1979) shows, the issue of legislative efficiency is closely related to cooperation among members of the legislature. Yet, political power exerted by self-interested minimum winning coalitions (e.g. Riker and Ordeshook (1973)) or agenda setters (e.g. Baron and Ferejohn (1989)) usually prevents legislatures from achieving an efficient allocation of public goods in static settings, even if there are no costs of employing a decision-making apparatus. As there is generally no efficiency-sustaining cooperative behavior in non-cooperative one-shot models with rational representatives, the problem of sustaining efficiency can only be addressed in a repeated game. Following the logic applied in previous chapters, we shall analyze the correlation between the size of a legislature and legislative efficiency with respect to public good provision. Furthermore, we shall compare the respective findings to results of repeated decentralized public good provision, as analyzed in Pecorino (1999).

The remainder of this chapter[67] is organized as follows. Section 5.2 presents a generalized version of the repeated agenda model employed in chapters 3 and 4 and derives a general necessary condition for sustaining cooperative outcomes in an economy with n regions. Section 5.3 applies the basic n-region agenda model to the problem of centralized administration of spillover policies, as introduced in subsection 3.3.1. As a central result, cooperation necessarily breaks down in large legislatures. The latter

[66] The formalized literature traces back to Buchanan and Tullock (1962), cha. 8. In this line, Baldwin et al. (2001) analyze obstacles for efficient decision-making in an enlarged European Union.

[67] Parts of this chapter are based on Koppel (2004a).

result carries over to section 5.4 and the local public goods setting analyzed there. In this section, public goods are provided subject to a fixed aggregate budget. Although individual risk-aversion and patience can be shown to facilitate cooperation among representatives, cooperation, once more, breaks down in large legislatures. Section 5.5 extends the local public goods analysis to endogenous tax revenues. Just like in the two previous sections, there exists a critical upper threshold of legislature size. Section 5.6 concludes.

5.2 Basic Model

Throughout this chapter, the economy consists of $i = 1, \ldots, n$ geographically distinct regions with $n \geq 2$. Immobile regional populations are normalized to 1. Public good policies are decided in a federal legislature with each region being represented by an outcome-motivated delegate. The legislature is presided over for one period by each region in turn.

The presidency is assigned the right to confront the legislature with a take-it-or-leave-it vote over any vector $(g_1, \ldots, g_n)$ of non-negative public good policies satisfying the section-specific budget restrictions. Furthermore, a proposal requires unanimous approval in order to be adopted. The status quo policies imply no public good provision at all. Like in the previous chapters, we assume that indifferent representatives approve the proposal.

Representatives interact over an infinite horizon, share perfect recall, and have a common discount factor $0 < \delta < 1$. Again, we abstract from polar (im)patience and the possibility of binding contracts and assume that representatives employ trigger-strategies in order to maintain the cooperative outcomes. In line with previous chapters, we shall explore the allocation of public goods. As our analysis is restricted to symmetric regions, the general trigger-strategy for a representative from region i reads as

$$\begin{array}{ll}
\text{propose } g^* \text{ for all regions} & \text{if } i = a \ \wedge \ t = 1 \\
\text{propose } g^* \text{ for all regions} & \text{if } i = a \ \wedge \ t > 1 \ \wedge \ h_t = \left(\left\{ \overrightarrow{g^*} \right\}_1, \ldots, \left\{ \overrightarrow{g^*} \right\}_{t-1} \right) \\
\text{propose } g^a, \ g^{\neg a} & \text{if } i = a \ \wedge \ t > 1 \ \wedge \ h_t \neq \left(\left\{ \overrightarrow{g^*} \right\}_1, \ldots, \left\{ \overrightarrow{g^*} \right\}_{t-1} \right) \\
\text{accept proposal} & \text{if } U_i^{PR} \geq U_i^{SQ}
\end{array}. \tag{5.1}$$

Once more, the superscripts PR and SQ denote proposal and status quo policies, respectively. Furthermore, g^*, g^a, and $g^{\neg a}$ represent the efficient public good quantities as well as quantities agenda setters propose for their own and remaining regions, respectively.

Turning to the general distribution of legislative benefits, let a denote the presidency's region, and consider the case of cooperative legislative behavior. Representatives then earn cooperative periodical payoffs π^* that amount to the familiar discounted payoffs

$$\Pi^* = \frac{1}{1-\delta}\pi^*. \tag{5.2}$$

Under an uncooperative legislature, presidencies rather use agenda power in a way to favour their own regions. Hence, a representative earns payoffs π^a every nth period that she is assigned agenda power and payoffs $\pi^{\neg a}$ in periods she is exposed to agenda power exerted by other regions' presidencies. Her discounted payoffs, therefore, read as[68]

$$\Pi^d = \frac{1}{1-\delta^n}\pi^a + \frac{1}{1-\delta}\frac{\delta - \delta^n}{1-\delta^n}\pi^{\neg a}. \tag{5.3}$$

Again, cooperation can be sustained if the discounted cooperative payoffs Π^* outweigh

[68] The relevant algebra for this section is relegated to appendix 5.A.1.

the discounted payoffs Π^d from an uncooperative legislature. After some straightforward computations, the general necessary condition for maintaining cooperation in the repeated game can be expressed as

$$\frac{\delta - \delta^n}{1 - \delta^n} \geq \frac{\pi^a - \pi^*}{\pi^a - \pi^{\neg a}}. \tag{5.4}$$

Note that, for $n = 2$, this condition corresponds to condition (3.20). To meet condition (5.4), the payoff ranking must, once more, satisfy $\pi^a > \pi^* > \pi^{\neg a}$.[69]

Let us apply the basic model to a specific problem of public good provision.

5.3 Spillovers

This section represents a synthesis of the frameworks in chapters 3 and 5 as it analyzes the impact of federal enlargements and spillovers on the ability to maintain cooperation in a unified framework. Let N represent the set of regions $1, \ldots, n$. In this section, an individual in region i is assumed to be represented by utility

$$U_i = \beta \ln \left(g_i + \phi \sum_{j \in N \setminus \{i\}} g_j \right) + x_i \qquad i = 1, \ldots, n. \tag{5.5}$$

Like in chapter 3, higher values of ϕ indicate that an individual in region i can enjoy public good provision in regions $j \neq i$ to a higher degree. Again, we assume $0 < \beta$ and $0 < \phi < 1$, i.e. demand for regional public goods is positive and includes a home bias. Furthermore, individuals are endowed with sufficient income ω to allow for positive private goods consumption, and prices for public (private) goods are set to $p(1)$.

[69] Indeed, this ranking is satisfied for the upcoming applications in sections 5.3 - 5.5, respectively.

5.3.1 Efficiency Benchmark

The efficient public good quantities maximize the aggregate public good surplus

$$S^{+} = \beta \sum_{i=1}^{n} \ln \left(g_i + \phi \sum_{j \in N \backslash \{i\}} g_j \right) - p \sum_{j \in N} g_j. \tag{5.6}$$

Differentiate (5.6) with respect to regional public good quantities, and rearrange the resulting first-order conditions to obtain the efficient quantities[70]

$$g^{*} = \frac{\beta}{p}. \tag{5.7}$$

The next two subsections follow the logic presented in subsections 3.3.1 and 3.3.2.

5.3.2 Centralized Regime

Under the centralized regime, public good provision is financed via identical head taxes

$$\tau_i = \frac{p}{n} \sum_{j \in N} g_j. \tag{5.8}$$

Given the taxation scheme (5.8), the public good surplus in region i read as

$$S_{iC} = \beta \ln \left(g_i + \phi \sum_{j \in N \backslash \{i\}} g_j \right) - \frac{p}{n} \sum_{j \in N} g_j. \tag{5.9}$$

Inserting the efficient quantities (5.7) into (5.9), the cooperative periodical payoffs read as

[70] See appendix 5.A.2 for the explicit derivation.

$$\pi^* = \beta \ln \frac{[1 + (n-1)\,\phi]\,\beta}{p} - \beta. \tag{5.10}$$

An uncooperative presidency rather proposes public goods quantities

$$\{g^a, g^{\neg a}\} = \left\{\frac{n\beta}{p}, 0\right\} \tag{5.11}$$

for her region and remaining regions, respectively. Remaining regions accept this proposal as it leaves them better off then the status quo. Hence, the stage game payoffs for a regional representative read as

$$\pi^a = \beta \ln \frac{n\beta}{p} - \beta \tag{5.12}$$

in case she is the agenda setter whereas she earns

$$\pi^{\neg a} = \beta \ln \frac{\phi n \beta}{p} - \beta \tag{5.13}$$

in case she is exposed to agenda power. What kind of effects do enlargements and spillovers now have on cooperation in the centralized setting?

Substituting (5.10), (5.12), and (5.13) into condition (5.4), the latter can be expressed as

$$\frac{\delta - \delta^n}{1 - \delta^n} \geq \frac{\ln \frac{n}{1+(n-1)\phi}}{\ln \frac{1}{\phi}} \tag{5.14}$$

for the spillover setting. Starting with the enlargement effect, we have the following proposition.

Proposition 9 *In the centralized spillover setting, cooperation cannot be sustained in large federations.*

Proof. Observe that $\frac{\partial \text{LHS (5.14)}}{\partial n} = \frac{-(1-\delta^n)\delta^n \ln\delta - (\delta-\delta^n)\delta^n \ln\delta}{(1-\delta^n)^2} = \frac{-\ln\delta(1-\delta)\delta^n}{(1-\delta^n)^2} > 0$. Furthermore, $\frac{\partial \text{RHS (5.14)}}{\partial n} = -\frac{1-\phi}{n[1+(n-1)\phi]}\frac{1}{\ln\phi} > 0$, i.e. both the LHS and the RHS of (5.14) increase monotonically in n. Finally, observe that $\lim_{n\to\infty}$RHS (5.14) $= 1$ and $\lim_{n\to\infty}$LHS (5.14) $= \delta$, where $\delta < 1$ holds by assumption. ■

There are two interesting effects regarding the correlation between the size of the legislature and the possibility of cooperation. For a representative, enlargements increase the time gap between her own presidencies, thus reducing the opportunities to harvest agenda gains. This *frequency effect* induces a positive impact by fostering the legislature's ability to maintain cooperation. The positive frequency effect can be depicted by the fact that $\frac{\partial \text{LHS (5.14)}}{\partial n} > 0$. On the other hand, enlargements alter the gain and costs of defection. Referring to its impact on cooperation in the present setting, we shall call this *payoff effect* negative. The negative payoff effect can be depicted by the fact that $\frac{\partial \text{RHS (5.14)}}{\partial n} > 0$.

Although (5.10), (5.12), and (5.13) increase in legislature size, respectively, there are clear-cut effects that explain why the payoff effect is negative. For a representative, the payoff difference between the two states of agenda power does not depend on the number of regions. If she is (not) assigned agenda power, there is (no) public good provision in her region. As the aggregate level of provision is the same in both states, the difference $\pi^a - \pi^{\neg a}$ is merely due to the degree of spillovers, i.e. to the extent to which a region may enjoy public goods that are provided in other regions.
On the other hand, $\pi^a - \pi^*$ increases in n because benefits from additional regions entering the federation are higher for an uncooperative representative using agenda power than for a representative under cooperation. The basic reason for this result is that a presidency is always better off channeling the lion's share of additional tax revenues to her own region than sharing additional tax revenues with other regions.

Accordingly, enlargements induce opposing effects on the ability to maintain cooperation in the spillover setting. Yet, the cooperation-deteriorating payoff effect outweighs the cooperation-enhancing frequency effect for sufficiently large n.

Before we discuss the implications of proposition 9, let us consider the correlation between spillovers and cooperation. The below lemma is needed for the proofs of propositions 11 and 13. Yet, as it is likewise helpful for understanding some of the below results, we state it in the main part of this chapter.

Lemma 10 *The ability to sustain cooperation increases in δ.*

Proof. We show that the LHS of (5.4) increases in δ for all values of n. Note that $\frac{\partial \text{LHS (5.14)}}{\partial \delta} = \frac{\left(1-n\delta^{n-1}\right)(1-\delta^n)+n\delta^{n-1}(\delta-\delta^n)}{(1-\delta^n)^2} = \frac{1+\delta^{n-1}[\delta(n-1)-n]}{(1-\delta^n)^2}$ which is positive if $\tilde{C} := 1 + \delta^{n-1}\left[\delta\left(n-1\right)-n\right] > 0$. We now establish that $\tilde{C}$ is positive for all values of n and δ. To this end, note that $\lim_{\delta\to 1}\tilde{C} = 0$ and $\tilde{C}_\delta = \delta^{n-1}\left(n-1\right) + \left[\delta\left(n-1\right)-n\right]\left(n-1\right)\delta^{n-2} = -\left(n-1\right)\delta^{n-2}n\left[1-\delta\right] < 0$. ■

In essence, this lemma implies that cooperation is most (least) likely sustainable with (im)patient representatives. Indeed, the lemma comes to no surprise as patience is well-understood to foster cooperation in repeated games.[71]

Turning to the spillover effect, the following proposition emerges.

Proposition 11 *For any δ and n, (i) cooperation can be sustained for sufficiently small spillovers, (ii) the ability to sustain cooperation decreases in spillovers, and (iii) cooperation cannot be sustained for sufficiently large spillovers.*

Proof. (i): Observe that $\lim_{\phi\to 0}\text{RHS (5.14)} = 0$, where LHS $(5.14) > 0$ holds for the restrictions imposed on δ and n. (ii): Note that $\frac{\partial \text{RHS (5.14)}}{\partial \phi} = \frac{\frac{1}{\phi}\ln\frac{n}{1+(n-1)\phi} - \frac{n-1}{1+(n-1)\phi}\ln\frac{1}{\phi}}{\left(\ln\frac{1}{\phi}\right)^2} = \frac{\frac{1+(n-1)\phi}{\phi}\ln\frac{n}{1+(n-1)\phi} - (n-1)\ln\frac{1}{\phi}}{[1+(n-1)\phi]\left(\ln\frac{1}{\phi}\right)^2}$ which is positive if $\tilde{D} := \frac{1+(n-1)\phi}{\phi}\ln\frac{n}{1+(n-1)\phi} - \left(n-1\right)\ln\frac{1}{\phi} > 0$. We now establish that $\tilde{D}$ is positive for all values of ϕ. To this end, observe

[71] A reexamination of this point is relegated to chapter 6.

that $\lim_{\phi\to 1}\tilde{D}=0$ and $\frac{\partial\tilde{D}}{\partial\phi}=\frac{(n-1)\phi-[1+(n-1)\phi]}{\phi^2}\ln\frac{n}{1+(n-1)\phi}-\frac{1+(n-1)\phi}{\phi}\frac{1+(n-1)\phi}{n}\frac{(n-1)n}{[1+(n-1)\phi]^2}+(n-1)\,\phi\frac{1}{\phi^2}=-\frac{1}{\phi^2}\ln\frac{n}{1+(n-1)\phi}<0$. Part (iii) requires that, for large values of ϕ, (5.14) is violated for all δ and n. According to lemma 10, condition (5.14) is most likely satisfied for large values of δ. Finally, observe that (by de L'Hôpital's rule) $\lim_{\delta\to 1}$RHS (5.14) $=\lim_{\phi\to 1}$LHS (5.14) $=\frac{n-1}{n}$, where $\delta<1$ holds by assumption. ■

In essence, this proposition extends the realm of proposition 3 to an economy with n regions. As the underlying intuition is the same as in the 2-region economy, we refer to chapter 3 and the interpretation developed there.

Let us now consider the implications of proposition 9 in more detail. This proposition implies that if cooperation can be maintained in small legislatures, then there exists a critical level of legislature size in a way that cooperation breaks down in larger legislatures. We shall identify this critical size for legislatures and analyze its characteristics.[72] Define $\hat{n}$ in a way that condition (5.14) is satisfied as a strict equality. Due to the complexity of (5.14), there is no closed form solution for $\hat{n}$. We, therefore, rely on simulations and apply the Newton method in order to determine $\hat{n}$. The respective procedures are relegated to appendix 5.A.3 and summarized in figure 5.1.

For selected values of the discount parameter δ, this figure depicts the critical legislature size $\hat{n}$ as a function of the spillover ϕ. In legislatures with less (more) than $\hat{n}$ representatives, cooperation is (not) sustainable. The following results can be depicted. For high spillovers and/or impatient representatives, cooperation cannot be sustained at all. Proposition 11 (iii) and lemma 10 already gave a hint at this result. Otherwise, there exists an admissible $\hat{n}\geq 2$. Observe that the critical legislature size decreases monotonically in ϕ. Hence, there is a clear-cut trade-off between legislature size and the normative aspects of centralized public good provision. Increasing a federation implies that cooperation can never be preserved for a larger range of public good policies compared to the pre-enlargement status. In fact, on the verge of breaking down,

[72] Calculations furthermore show that if cooperation cannot be sustained in small legislatures, it cannot be sustained in large legislatures, either. See appendix 5.A.4.

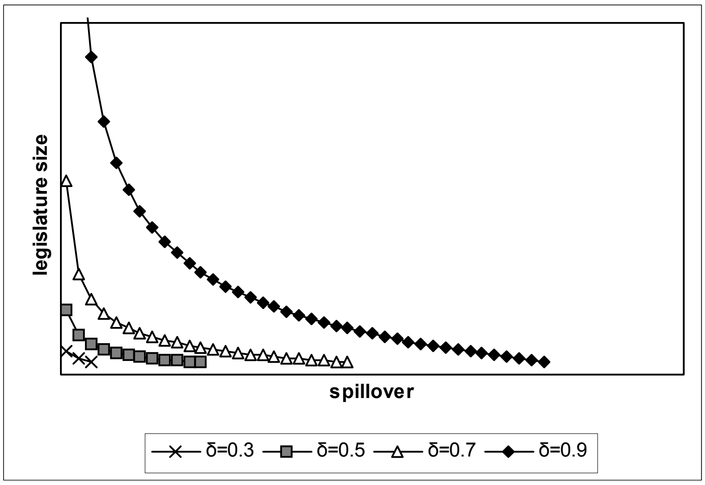


Figure 5.1: Critical legislature sizes for the spillover setting

cooperation can only be maintained for a strictly smaller set of policies. Note that $\hat{n}$ furthermore increases in δ, i.e. maintaining cooperation in small legislatures requires less patience from legislators. This is an interesting implication of the familiar result we had in lemma 10.

Summarizing the results, efficient centralized public good provision is more (less) likely sustainable in small (large) legislatures, with (im-)patient representatives, and small (large) interregional policy externalities. Let us now analyze the correlation between federal enlargements and cooperation for a decentralized regime.

5.3.3 Decentralized Regime

The basic structure of the voluntary contribution game is the very same as in chapter 3. In particular, the critical discounting parameter for maintaining cooperation in the repeated game exhibits the same structure like the one in condition (3.30). The mere purpose for the first part of this subsection is to derive the various payoff measures for the n-region economy. We present the respective final results whereas the explicit derivation is relegated to appendix 5.A.2.

Under the decentralized regime, public goods are, once more, financed at the regional layer. The public good surplus in region i, therefore, read as

$$S_{iD} = \beta \ln \left(g_i + \phi \sum_{j \in N \setminus \{i\}} g_j \right) - p g_i. \tag{5.15}$$

The cooperative quantities and payoffs can be depicted by (5.7) and (5.10), respectively. In the stage game equilibrium, representatives contribute quantities

$$g^e = \frac{1}{1 + (n-1)\phi} \frac{\beta}{p} \tag{5.16}$$

that amount to stage game equilibrium payoffs

$$\pi^e = \beta \ln \frac{\beta}{p} - \frac{\beta}{1 + (n-1)\phi}. \tag{5.17}$$

Anticipating her counterparts' cooperative contributions, a defecting representative contributes

$$g^d = \max \{1 - (n-1)\phi, 0\} \frac{\beta}{p} \tag{5.18}$$

and reaps payoffs

$$\pi^d = \beta \ln \left(\frac{\max \{1, (n-1)\phi\} \beta}{p} \right) - \max \{1 - (n-1)\phi, 0\} \beta. \tag{5.19}$$

Recall that a defecting representative still contributes a positive quantity in the 2-region economy, as described in chapter 3, whereas she fully withdraws her contribution in the n-region economy in case of a sufficiently large number of regions.

Inserting (5.10), (5.17), and (5.19) into (3.30), the critical discounting parameter under the decentralized regime can be expressed as

$$\delta^D = \frac{\ln \max\left\{\frac{1}{1+(n-1)\phi}, \frac{(n-1)\phi}{1+(n-1)\phi}\right\} - \max\{1-(n-1)\phi, 0\} + 1}{\ln \max\{1, (n-1)\phi\} - \max\{1-(n-1)\phi, 0\} + \frac{1}{1+(n-1)\phi}}. \tag{5.20}$$

What can we say about the enlargement effect in the decentralized setting?

Proposition 12 *In the decentralized spillover setting, cooperation can be sustained in large federations.*

Proof. It is readily checked that $\lim_{n\to\infty} \delta^D = 0$ as the numerator (denominator) of (5.20) converges to $1\,(\infty)$ for $n \to \infty$. ■

Proposition 12 is similar to result 2 in Pecorino (1999). Yet, Pecorino applies a more general type of quasi-linear utility but restricts his analysis to pure public goods. We assume a more specific type of utility and allow for various degrees of interregional spillovers.

The result in proposition 12 is due to the following logic. As the number of regions (and thus the number of contributors) increases, a defecting representative more and more retains her contribution whereas the individual cooperative contribution is fixed. Eventually, a defecting representative fully withdraws her contribution. Hence, the gain from defection, as measured by $\pi^d - \pi^*$, increases only for small n but is bounded above for large n. Offsetting this effect, the individual stage game equilibrium contribution strictly decreases in n, implying a monotonically increasing gain from cooperation $\pi^* - \pi^e$. In the limiting case of $n \to \infty$, the gain from defection is, therefore, fixed whereas the gain from cooperation converges to infinity. Hence, efficient decentralized public good provision is possible in sufficiently large federations.

Unfortunately, this limit result is about all we can say about the correlation between the number of regions and the ability to maintain cooperation in the decentralized setting. As Pecorino acknowledges for his specifications, "*there are no monotonicity results for the effect of* n *on* δ^* *(the derivative of* δ^* *with respect to* n *is generally indeterminate).*"[73] Suffering from the very same problem, we cannot derive a clear-cut correlation in our decentralized setting. Compared to the centralized setting, spillovers and the number federal member states now induce an ambiguous effect on the ability to sustain cooperation. Although our genuine results for the centralized setting show clear-cut correlations, a comparison between both regimes can, therefore, yield only limited results, and we abstract from a regime ranking subsection. Yet, some implications can be derived.

It is obvious that the result in proposition 12 is at odds with the result in proposition 9. Comparing these results, public goods should be provided at the decentral layer whenever the size of the federation is sufficiently large. Furthermore, efficient policies are always easier to sustain under a decentralized (centralized) regime for goods entailing significant (negligible) spillovers. Note that the latter results carry over from the 2-region economy of chapter 3.

Generally speaking, proposition 9 sends a discouraging signal concerning centralized public good provision in large federations. We shall now scrutinize the robustness of this result by allowing for different public good settings.

5.4 Dividing-the-pie

Let us return to the basic n-region model of centralized public good provision, as introduced in section 5.2. For the remainder of the present section, an individual in region i is represented by utility

$$U_i = \beta \frac{(g_i)^{1-\alpha}}{1-\alpha} \tag{5.21}$$

[73]Pecorino (1999), p. 129. In his paper, δ^* is the analog to our δ^D. He finds that the lack of monotonicity emerges for Cobb-Douglas utility, too.

with $0 < \alpha < 1$ and $0 < \beta$.[74] Again, g_i denotes a local public good provided in region i. Furthermore, let T represent an exogenous budget to be spent on public goods at costs of p per unit g_i.[75] The presidency may now propose any vector $(g_1, \ldots, g_n)$ of non-negative regional public good quantities satisfying the budget constraint

$$p \sum_{i=1}^{n} g_i \leq T. \tag{5.22}$$

Employing the familiar closed-rule unanimity voting procedures, the proposal becomes implemented if no representative vetoes its implementation.

Let us now turn to the distribution of legislative benefits under a cooperative legislature. Given the regional utility (5.21) and the budget constraint (5.22), cooperative presidencies allocate the surplus-maximizing public good quantities

$$g^* = \frac{T}{np} \tag{5.23}$$

to each region, i.e. each region enjoys an equal share of the pie. Substituting (5.23) into (5.21), representatives receive periodical payoffs

$$\pi^* = \beta \frac{\left(\frac{T}{np}\right)^{1-\alpha}}{1-\alpha}, \tag{5.24}$$

in case the legislature pursues cooperation. If, on the other hand, presidencies merely benefit their own regions, the presidency's proposal allocates public good quantities

[74] Specified as a *Bernoulli function*, this type of utility exhibits constant relative risk-aversion. It is, therefore, known as *CRRA*-utility. The parameter α measures the degree of risk-aversion. See Mas-Colell, Whinston and Green (1995), p. 194.

[75] The genuine notion *dividing-the-pie* refers to the problem of allocating a fixed amount of benefits among a fixed number of recipients. See, e.g. Baron and Ferejohn (1989).

$$\{g^a, g^{\neg a}\} = \left\{\frac{T}{p}, 0\right\}. \tag{5.25}$$

Remaining regions accept this proposal as it leaves them indifferent to the status quo of no public good provision. Substitute (5.25) into (5.21). Under an uncooperative legislature, a representative then earns payoffs

$$\pi^a = \beta \frac{\left(\frac{T}{p}\right)^{1-\alpha}}{1-\alpha} \tag{5.26}$$

every nth period that she is assigned agenda power whereas she reaps payoffs

$$\pi^{\neg a} = 0 \tag{5.27}$$

in case she is exposed to agenda power. Inserting the above expressions for π^*, π^a, and $\pi^{\neg a}$ into (5.4), the condition for maintaining cooperation in the dividing-the-pie setting can be expressed as

$$\frac{\delta - \delta^n}{1 - \delta^n} \geq 1 - \left(\frac{1}{n}\right)^{1-\alpha}. \tag{5.28}$$

Before we get to the effects of enlarging the federation, we shall state the correlation between individual risk-aversion and cooperation in the following proposition.

Proposition 13 *For any δ and n, (i) cooperation can be sustained for sufficiently high risk-aversion, (ii) the ability to sustain cooperation increases in the degree of risk-aversion, and (iii) cooperation cannot be sustained for sufficiently low risk-aversion.*

Proof. (i): Lemma 10 implies that condition (5.28) is most likely violated for small values of δ. Observe that $\lim_{\delta \to 0}$LHS (5.28) $= \lim_{\alpha \to 1}$RHS (5.28) $= 0$, where $\delta > 0$

holds by assumption. (ii): Note that $\frac{\partial \text{RHS (5.28)}}{\partial \alpha} = \left(\frac{1}{n}\right)^{1-\alpha} \ln \frac{1}{n} < 0$. (iii): Lemma 10 implies that condition (5.28) is most likely satisfied for large values of δ. Observe that (by de L'Hôpital's rule) $\lim_{\delta\to1}$LHS (5.28) $= \lim_{\alpha\to0}$RHS (5.28) $= \frac{n-1}{n}$, where $\delta < 1$ holds by assumption. ■

Why does risk-aversion induce a positive impact on the legislature's ability to sustain cooperative outcomes? This result is due to the fact that uncooperative legislative behavior entails unpleasant benefit volatility. Whereas the parameter α is usually interpreted as a measure for individual risk-aversion, we can interpret α as the individual preference for consumption smoothing over time for the problem at hand. For αs close to 1, representatives perceive an exclusion from legislative benefits utmost unpleasant. As a consequence, any incentives to harvest agenda gains vanish. The vice versa result is obtained for small αs. In this case, representatives do not care about the volatility of legislative benefits, and any incentives to abstain from using agenda power disappear.

The findings in proposition 13, once more, bear an interesting analogy to results from the universalism literature of distributive politics. Again, narrow pursuit of self-interest is the only equilibrium prediction if we look at our model from a one-shot perspective. Yet, we show that if there is sufficient fear concerning the consequences of being excluded from legislative benefits, the repetition inherent in legislative interaction may yield ex-post-viable incentives for cooperative behavior, i.e. legislators may cooperate even once political power has been assigned.

Let us now turn to the correlation between federal enlargements and cooperation. The following proposition is readily established.

Proposition 14 *In the dividing-the-pie setting, cooperation cannot be sustained in large legislatures.*

Proof. Recall that $\frac{\delta-\delta^n}{1-\delta^n}$ increases monotonically in n. Furthermore, $\frac{\partial \text{RHS (5.28)}}{\partial n} = \frac{1-\alpha}{n^{2-\alpha}} > 0$, i.e. both the LHS and the RHS of (5.28) increase monotonically in n.

Finally, observe that $\lim_{n\to\infty}$RHS (5.28) $= 1$ and $\lim_{n\to\infty}$LHS (5.28) $= \delta$, where $\delta < 1$ holds by assumption. ■

Note that this is the very same result as in proposition 9. Yet, the underlying intuition is a different one. Proposition 14 can be explained by the fact that an uncooperative presidency always allocates the whole pie of benefits to her own region. Hence, the payoffs π^a and $\pi^{\neg a}$ do not depend on the size of the federation. Maintaining cooperation in an enlarged legislature implies, though, that a fixed pie is divided among a larger number of beneficiaries. Payoffs π^*, therefore, decrease in n and converge towards $\pi^{\neg a}$ for large federations. Accordingly, the gain from cooperation, $\pi^* - \pi^{\neg a}$, decreases in the number of regions and even vanishes for sufficiently large federations whereas the gain from defection, $\pi^a - \pi^*$, even increases in n. Hence, the payoff effect is, once more, negative and eventually outweighs the positive frequency effect for sufficiently large n.

Proposition 14 furthermore implies that if cooperation can be maintained in small legislatures, then there exists a critical level of legislature size $\hat{n}$ in a way that cooperation breaks down for $n > \hat{n}$. Like in the spillover setting, there is no closed form solution for $\hat{n}$, and we rely on simulations, i.e. we determine $\hat{n}$ via the Newton method. The results are summarized in figure 5.2.[76]

For selected values of the discount parameter δ, this figure depicts the critical legislature size $\hat{n}$ as a function of individual risk-aversion α. Like in the previous section, cooperation can be sustained for $n \leq \hat{n}$. Note that $\hat{n}$ again increases in δ. Due to the logic underlying proposition 13, $\hat{n}$ increases in α whereas an admissible $\hat{n} \geq 2$ does not exist for small αs. The prospects of efficient centralized public good provision are, therefore, rather limited. If at all, efficiency is sustainable in small legislatures and/or with pretty risk-averse representatives, but provision necessarily entails inefficiencies in large legislatures.

[76] The corresponding procedures can be found in appendix 5.A.3. Again, if cooperation cannot be sustained in small legislatures, it cannot be sustained in large legislatures, either (see appendix 5.A.4).

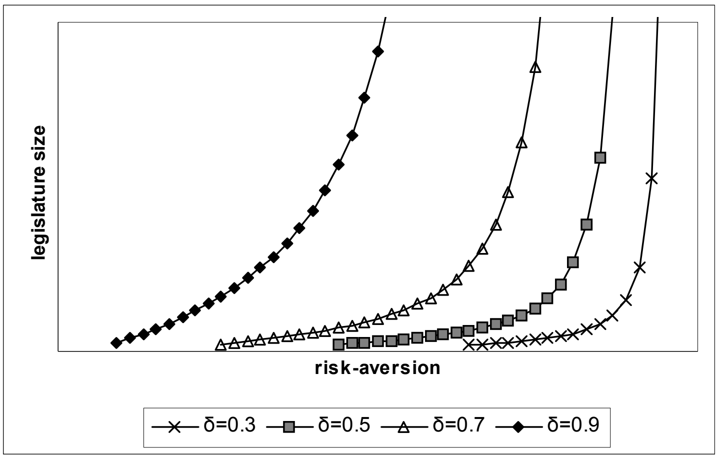


Figure 5.2: Critical legislature sizes for the dividing-the-pie setting

Let us confront these results with a decentralized regime. Recall that the problem at hand is an allocation of pure local public goods, i.e. a decentralized regime already yields first best results from a static perspective. From a static point of view, we already know that centralizing low-spillover policies usually entails efficiency losses (see, e.g. proposition 2). Yet, as propositions 3 (i) and 11 (i) show, the respective efficiency losses may be avoided in a dynamic setting. Putting this optimistic evaluation of the centralized regime into perspective, proposition 13 indicates that the results may be supported by a sizable degree of risk-aversion.[77] Anyway, the results in this section question the case for centralizing pure local public good policies as the centralized regime can never do better than the decentralized regime.

The inefficiencies associated with an enlargement are due to the dominant effect legislature enlargements induce on the cooperative payoffs π^*. As this effect is related to the fixed-budget structure of the allocation problem, the next section, furthermore, allows for additional regions to contribute additional means to the aggregate public

[77] Recall that we employ logarithmic utility in the various spillover settings, and observe that $\lim\limits_{\alpha\to 1} \frac{(g_i)^{1-\alpha}}{1-\alpha} = \ln g_i$. See Mas-Colell, Whinston and Green (1995), p. 211.

good budget.

5.5 Endogenous Budget

Again, let us build on the basic n-region model of centralized public good provision, as introduced in section 5.2. For the present section, let individual preferences be represented by utility

$$U_i = \beta\Psi\left(g_i\right) + x_i, \tag{5.29}$$

and let individuals be endowed with sufficient income to allow for positive consumption of the private good x. We impose the usual restrictions $\Psi' > 0, \Psi'' < 0$, i.e. the marginal public good utility is positive and decreasing. Furthermore, we assume $\Psi\left(0\right) = 0$. Again, let N represent the set of regions $1, \ldots, n$.

Public goods are financed via identical head taxes $\tau_i = \frac{p}{n}\sum_{j\in N} g_j$. Given this taxation scheme, the regional public good surplus reads as

$$S_i = \beta\Psi\left(g_i\right) - \frac{p}{n}\sum_{j\in N} g_j. \tag{5.30}$$

Once more, cooperative agenda setters propose efficient policies. These efficient policies maximize the aggregate public good surplus, implying

$$g_i^* = \arg\max_{g_i\geq 0}\left\{\beta\sum_{j\in N}\Psi\left(g_j\right) - p\sum_{j\in N} g_j\right\}. \tag{5.31}$$

as well as the resulting regional Samuelson-conditions

$$\beta\Psi'\left(g_i^*\right) = p. \tag{5.32}$$

According to (5.32), the efficient public good quantity does not depend on n. Contrasting the results of the previous 2 sections, payoffs π^* do not depend on the number of regions anymore.

An uncooperative agenda setter maximizes (5.29) subject to both the taxation constraint and the constraint of unanimous approval for her policy proposal.[78] The latter constraint implies that

$$\beta\Psi\left(g_i\right) - \frac{p}{n}\sum_{j\in N} g_j \geq 0 \tag{5.33}$$

must be satisfied for all regions, i.e. the respective regional public good surplus must not fall short of the (zero) surplus associated with status quo policies. Standard reasoning implies that the presidency's proposal satisfies (5.33) with equality for all remaining regions. If (5.33) did not bind for a specific remaining region, the presidency could reduce provision in that region without loosing support for her proposal. Such a reduction is clearly in the presidency's interest since she is due to contribute means to public good provision in other regions whereas she does not enjoy benefits from the latter. In this setting, the presidency faces a lower bound when trying to reduce public good provision in remaining regions. This lower bound is implicitly characterized by (5.33) being satisfied as a strict equality. In equilibrium, (5.33) is satisfied as a strict equality for all remaining regions. The latter, therefore, receive identical public good quantities $g^{\neg a}$ and merely obtain fixed default payoffs. These payoffs may differ in the amount of exogenous income. Yet, they do not vary in n.

In equilibrium, the presidency's approval constraint is certainly not satisfied as a strict equality as she can use agenda power to provide her region with a quantity $g^a > g^{\neg a}$. Consider now a legislature enlargement, and suppose that the presidency continues

[78] Persson (1998), pp. 315, instructively derives a minimum winning coalitions equilibrium for local public goods in a one-shot setting. His reasoning is readily applied to our unanimity setting.

to propose quantities g^a and $g^{\neg a}$. The quantity $g^{\neg a}$ allocated to the new region then lowers average provision and, hence, regional tax burdens. An agenda setter could, therefore, easily allocate some additional tax revenue to increase g^a without losing support for her proposal.[79] Hence, the payoffs π^a increase monotonically in n whereas the payoffs π^* and $\pi^{\neg a}$ represent fixed values. Like in sections 5.3 and 5.4, the payoff effect is negative, the section-specific term representing the RHS of (5.4), therefore, increases monotonically in n, converging to unity for $n \to \infty$. At the same time, the LHS converges to $\delta < 1$. These results motivate the following proposition.

Proposition 15 *In the endogenous budget setting, cooperation cannot be sustained in large legislatures.*

Note that proposition 15 confirms the respective results in propositions 9 and 14. The current proposition is essentially driven by the presidency's ability to channel tax revenue, in particular the one that is generated in additional regions, to her own region.

5.5.1 Numerical Example

We shall now illustrate the above results by restricting the utility in (5.29) to $\Psi(g_i) = 2\sqrt{g_i}$. The regional public good surplus in (5.30) then reads as

$$S_i = 2\beta\sqrt{g_i} - \frac{p}{n}\sum_{j\in N} g_j. \tag{5.34}$$

According to (5.32), cooperation now entails regional quantities

$$g^* = \left(\frac{\beta}{p}\right)^2. \tag{5.35}$$

Inserting (5.35) into (5.34), representatives reap cooperative payoffs

[79] This is not to say that she will optimally behave this way but rather illustrates that she can always receive higher payoffs in larger federations. As the example in subsection 5.5.1 shows, the presidency may rather optimally adjust her proposal by increasing both g^a and $g^{\neg a}$.

$$\pi^* = \frac{\beta^2}{p}. \tag{5.36}$$

A deviating presidency rather proposes quantities that maximize (5.34) subject to the regional approval constraints. The corresponding Lagrange-program can be expressed as

$$\begin{aligned} &\max_{g^a, g^{\neg a}} \; L = S^a + \lambda \left\{ S^{\neg a} - 0 \right\} \qquad (5.37) \\ = \; & 2\beta\sqrt{g^a} - \frac{p}{n}\left[g^a + (n-1)\,g^{\neg a}\right] + \lambda \left\{ 2\beta\sqrt{g^{\neg a}} - \frac{p}{n}\left[g^a + (n-1)\,g^{\neg a}\right] \right\}. \end{aligned}$$

Solving (5.37)[80], the presidency proposes quantities

$$\{g^a, g^{\neg a}\} = \left\{ \frac{n\beta^2}{p^2}, \frac{n\beta^2}{\left(\sqrt{n}+1\right)^2 p^2} \right\}. \tag{5.38}$$

Note that both g^a and $g^{\neg a}$ increase in n, i.e. average public good provision is higher in large federations.[81] This is due to the fact that a region's approval is easier to obtain by (marginally) increasing provision in that region than by (marginally) reducing that region's tax share. Substituting (5.38) into (5.34), an uncooperative presidency reaps payoffs

$$\pi^a = \frac{2n}{\sqrt{n}+1}\frac{\beta^2}{p} \tag{5.39}$$

whereas representatives exposed to agenda power earn payoffs

[80] See appendix 5.A.5 for the corresponding algebra.

[81] Recalling our literature survey, Persson and Tabellini (1994) find that the level of regional public goods is always higher under a centralized regime. The authors, furthermore, show that regional provision under a centralized regime increases in the number of federal member regions.

$$\pi^{\neg a} = 0. \tag{5.40}$$

Substituting (5.36), (5.39), and (5.40) into condition (5.4), the necessary condition for maintaining cooperation in the endogenous budget setting can be expressed as

$$\frac{\delta - \delta^n}{1 - \delta^n} \geq 1 - \frac{1}{2\sqrt{n}} - \frac{1}{2n}. \tag{5.41}$$

Illustrating proposition 15, it is readily checked that the RHS of (5.41) increases monotonically in n and converges to 1 for $n \to \infty$ whereas the LHS of (5.41) does not exceed δ. Following the logic from the two previous sections, a critical legislature size $\hat{n}$ exists in a way that cooperation breaks down for $n > \hat{n}$. Again, we rely on simulations and determine the critical legislature size via the Newton method.[82] The simulations are relegated to appendix 5.A.3 and summarized in figure 5.3.

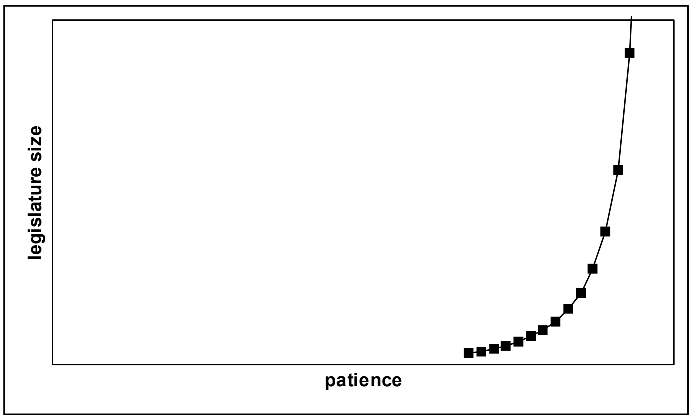


Figure 5.3: Critical legislature sizes for the endogenous budget setting

This figure depicts the critical legislature size $\hat{n}$ as a function of the discount parameter

[82] Once more, if cooperation cannot be sustained for $n = 2$, it cannot be sustained for $n > 2$, either (see appendix 5.A.4).

δ.[83] Whereas cooperation cannot be sustained at all for small and medium values of δ, an admissible $\hat{n} \geq 2$ exists for large values of δ. Furthermore, $\hat{n}$ increases in δ, i.e. maintaining cooperation in large legislatures requires a higher degree of patience from legislators.

Just like in section 5.4, the ranking of regimes is readily established. As the latter are confronted with the problem of allocating pure local public goods, the decentralized allocation is already first best in the one-shot setting whereas centralization entails inefficiencies. Although the latter may be overcome in the repeated game, the centralized regime can never do better than the decentralized regime. In particular, centralization is likely to entail inefficiencies in large federations. Hence, pure local public good policies should be assigned to the decentral layer.

5.6 Conclusion Chapter 5

Depending on the number of regions adhering to a federation, should public good policies be centralized or rather assigned to the decentral layer? This chapter has analyzed the impact of enlargements on the regime-specific ability to yield efficient outcomes. In section 5.3, public good policies induce interregional spillovers. In this case, centralized public good provision necessarily entails inefficiencies in large federations. Precisely, if cooperation is possible in small legislatures, then it breaks down in large legislatures. On the other hand, efficiency can rather be sustained in large federations if regions contribute on a voluntary basis. Efficient public good policies are, therefore, more likely to emerge from decentralization in case a federation consists of many members.

Sections 5.4 and 5.5, furthermore, confirm the negative correlation between the number of member states and cooperation at the federal layer for local public good frameworks. In these sections, there likewise exists a critical number of member-regions in a way that

[83] Note that $\hat{n}$ now merely depends on δ whereas the critical legislature size was characterized by two arguments in the two previous sections, respectively.

centralized public good provision necessarily entails inefficiencies in larger federations. Sections 5.4 identifies individual risk-aversion as being an efficiency-facilitating element of centralized public good provision.

Of course, we do not find completely general results as we do not deal with completely general preferences. Although the negative correlation between a federation's number of participants and the likeliness of centralized efficiency proves robust in all our frameworks, we do not generalize this result. There might be payoff structures in a way that the RHS of (5.4) decreases in n, i.e. enlargements dilute payoff-based incentives to abuse agenda power. In such a setting, cooperation becomes even easier to sustain as the size of the federation increases. And even if enlargements induce a negative payoff effect, the positive frequency effect might still prevail. Considering the driving forces characterizing the respective payoff effects in sections 5.3, 5.4, and 5.5, this possibility is, though, anything but obvious.

We have, so far, analyzed the impact of three different determinants on the regime-specific ability to sustain cooperative public good policies. In these settings, the respective ability is determined both by the payoff structure of the underlying game as well as by the degree of patience associated with decision makers. The respective payoffs depend on strategy choices and may, therefore, be considered endogenous. On the other hand, discounting is exogenous in the sense that the individual discounting parameter is fixed. Whereas this is certainly the natural framework for outcome-motivated decision makers, discounting is rather unlikely to be exogenous if decision makers are office-motivated. In this case, the latter may act in a way to foster their chances for another term in office, i.e. strategy choices may most importantly affect an representative's likeliness to 'make it to the next stage' of the repeated game. Concluding our analysis of determinants for cooperative public good provision, the next section, therefore, endogenizes the formerly exogenous degree of patience by allowing for strategy-contingent discounting.

5.A Appendix Chapter 5

5.A.1 Derivation of (5.3) and (5.4)

As shown in previous chapters, cooperation entails discounted payoffs $\Pi^* = \frac{1}{1-\delta}\pi^*$. Defection entails discounted payoffs

$$\begin{aligned} \Pi^d &= \pi^a + \delta\pi^- + \ldots + \delta^{n-1}\pi^{\neg a} + \delta^n\pi^a + \ldots + \delta^{n+1}\pi^{\neg a} \qquad (5.42) \\ &= \sum_{t=0}^{\infty}\delta^{nt}\pi^a + \left(\delta + \ldots + \delta^{n-1}\right)\sum_{t=0}^{\infty}\delta^{nt}\pi^{\neg a} = \frac{1}{1-\delta^n}\pi^a + \frac{\delta-\delta^n}{1-\delta}\frac{1}{1-\delta^n}\pi^{\neg a}. \end{aligned}$$

Cooperation can be sustained if

$$\begin{aligned} \Pi^* \geq \Pi^d \quad &\Leftrightarrow \quad \frac{1}{1-\delta}\pi^* \geq \frac{1}{1-\delta^n}\pi^a + \frac{1}{1-\delta}\frac{\delta-\delta^n}{1-\delta^n}\pi^{\neg a} \qquad (5.43) \\ &\Leftrightarrow \quad \left(\frac{\delta-1}{1-\delta^n}+1\right)\pi^a - \frac{\delta-\delta^n}{1-\delta^n}\pi^{\neg a} \geq \pi^a - \pi^* \Leftrightarrow \frac{\delta-\delta^n}{1-\delta^n} \geq \frac{\pi^a-\pi^*}{\pi^a-\pi^{\neg a}}. \end{aligned}$$

5.A.2 Derivation of g^*, g^e, and g^d

Let N represent the set of regions $1, \ldots, n$. The regional utility in the n-region economy is characterized by

$$U_i = \beta \ln\left(g_i + \phi \sum_{j\in N\setminus\{i\}} g_j\right) + x_i. \qquad (5.44)$$

This utility implies an aggregate public good surplus

$$S^+ = \beta\sum_{i=1}^{n}\ln\left(g_i + \phi\sum_{j\in N\setminus\{i\}} g_j\right) - p\sum_{j\in N} g_j. \qquad (5.45)$$

Derivation of g^*: The efficient public good quantities obey the regional Samuelson-conditions. Hence, differentiate (5.45) with respect to g_i to obtain

$$\frac{\partial S^+}{\partial g_i} = \frac{\beta}{g_i^* + \phi \sum_{j \in N \setminus \{i\}} g_j^*} + \sum_{j \in N \setminus \{i\}} \frac{\beta \phi}{g_j^* + \phi \sum_{h \in N \setminus \{j\}} g_h^*} = p \qquad i = 1, \ldots, n. \quad (5.46)$$

Equate the Samuelson-conditions in (5.46) for any two regions k and l to obtain

$$\begin{aligned} & \frac{\beta}{g_k^* + \phi \sum_{j \in N \setminus \{k\}} g_j^*} + \sum_{j \in N \setminus \{k\}} \frac{\beta \phi}{g_j^* + \phi \sum_{h \in N \setminus \{j\}} g_h^*} \\ = \; & \frac{\beta}{g_l^* + \phi \sum_{j \in N \setminus \{l\}} g_j^*} + \sum_{j \in N \setminus \{l\}} \frac{\beta \phi}{g_j^* + \phi \sum_{h \in N \setminus \{j\}} g_h^*}. \end{aligned} \quad (5.47)$$

Note that $n-2$ terms on both sides of the equation are identical. Equation (5.47) can, therefore, be simplified to

$$\frac{(1-\phi)\,\beta}{g_k^* + \phi \sum_{j \in N \setminus \{k\}} g_j^*} = \frac{(1-\phi)\,\beta}{g_l^* + \phi \sum_{j \in N \setminus \{l\}} g_j^*} \Leftrightarrow g_k^* + \phi g_l^* = g_l^* + \phi g_k^* \Leftrightarrow g_k^* = g_l^* = g^*. \quad (5.48)$$

Insertion into (5.46) finally yields

$$\begin{aligned} & \frac{\beta}{g^* + (n-1)\,\phi g^*} + (n-1)\,\frac{\beta \phi}{g^* + (n-1)\,\phi g^*} - p = 0 \\ \Leftrightarrow \quad & p g^* \left[1 + (n-1)\,\phi\right] = \beta \left[1 + (n-1)\,\phi\right] \Leftrightarrow g^* = \frac{\beta}{p}. \end{aligned} \quad (5.49)$$

These quantities represent the efficient quantities in (3.4) and (5.7), respectively.

Derivation of g^e: Under a decentralized regime, the regional public good surplus reads as

$$S_{iD} = \beta \ln \left(g_i + \phi \sum_{j \in N \setminus \{i\}} g_j \right) - p g_i \qquad i = 1, \ldots, n. \quad (5.50)$$

Differentiate (5.50) with regard to g_i to obtain the reaction functions. In equilibrium, these reaction functions satisfy

$$\frac{\beta}{g_i^e + \phi \sum_{j \in N \setminus \{i\}} g_j^e} - p = 0 \qquad i = 1, \ldots, n. \tag{5.51}$$

Again, equate these equations for any two regions k and l to obtain

$$\frac{\beta}{g_k^e + \phi \sum_{j \in N \setminus \{k\}} g_j^e} = \frac{\beta}{g_l^e + \phi \sum_{j \in N \setminus \{l\}} g_j^e} \Leftrightarrow g_k^e + \phi g_l^e = g_l^e + \phi g_k^e \Leftrightarrow g_k^e = g_l^e = g^e. \tag{5.52}$$

Insertion into (5.51) yields $g^e = \frac{1}{1+(n-1)\phi} \frac{\beta}{p}$. The quantities in (3.15) correspond to $g^e|_{n=2}$.

Derivation of g^d: Recall that cooperative representatives provide $g^* = \frac{\beta}{p}$. A defecting representative, therefore, chooses her contribution g_i^d in a way that

$$g_i^d = \arg\max_{g_i \geq 0} \ \{\beta \ln [g_i + (n-1)\phi g^*] - p g_i\}. \tag{5.53}$$

Differentiate the maximand in (5.53) with respect to g_i. As the representative does not necessarily contribute a positive quantity, the optimal contribution is characterized by

$$\frac{\beta}{g_i^d + (n-1)\phi \frac{\beta}{p}} - p \leq 0. \tag{5.54}$$

Obeying the non-negativity constraint, a defecting representative, therefore, contributes $g^d = \max \left\{ \frac{\beta}{p} [1 - (n-1)\phi], 0 \right\}$. The quantities in (3.28) correspond to $g^d\big|_{n=2}$.

5.A.3 Calculating $\hat{n}$

Section 5.3: Determining the critical legislature size in the spillover setting, we use the Newton iteration method (10-digit precision) to solve the strict equality of

$$\frac{\delta - \delta^n}{1 - \delta^n} - \frac{\ln \frac{n}{1+(n-1)\phi}}{\ln \frac{1}{\phi}} \geq 0 \tag{5.55}$$

for $n \geq 2$. Columns $2-5$ of table 5.1 show the values of $\hat{n}$ for selected configurations of ϕ and δ. A $(-)$ indicates that there exists no admissible $\hat{n} \geq 2$ for the respective combination of ϕ and δ.

ϕ	$\delta = 0.3$	$\delta = 0.5$	$\delta = 0.7$	$\delta = 0.9$
0.01	4	11	33	169
0.05	2	5	13	54
0.09	–	4	9	36
0.13	–	3	7	28
0.17	–	3	6	23
0.21	–	2	5	19
0.25	–	–	4	16
0.29	–	–	4	14
0.33	–	–	3	12
0.37	–	–	3	11
0.41	–	–	3	10
0.45	–	–	2	8
0.49	–	–	–	7
0.53	–	–	–	6
0.57	–	–	–	6
0.61	–	–	–	5
0.65	–	–	–	4
0.69	–	–	–	4
0.73	–	–	–	3
0.77	–	–	–	2
0.81	–	–	–	–

Table 5.1: Critical legislature sizes for the spillover setting

Section 5.4: Determining the critical legislature size in the dividing-the-pie setting, we use the Newton iteration method (10-digit precision) to solve the strict equality of

$$\frac{\delta - \delta^n}{1 - \delta^n} - 1 + (1/n)^{1-\alpha} \geq 0 \tag{5.56}$$

for $n \geq 2$. Columns $2-5$ of table 5.2 show values of $\hat{n}$ for selected configurations of α and δ. A $(-)$ indicates that there exists no admissible $\hat{n} \geq 2$ for the respective combination of α and δ.

$\boldsymbol{\alpha}$	$\boldsymbol{\delta = 0.3}$	$\boldsymbol{\delta = 0.5}$	$\boldsymbol{\delta = 0.7}$	$\boldsymbol{\delta = 0.9}$
0.07	–	–	–	–
0.11	–	–	–	4
0.15	–	–	–	7
0.19	–	–	–	10
0.23	–	–	–	14
0.27	–	–	3	19
0.31	–	–	4	25
0.35	–	–	5	33
0.39	–	–	6	43
0.43	–	2	7	57
0.47	–	3	9	77
0.51	–	3	11	110
0.55	–	4	14	167
0.59	–	5	19	275
0.63	2	6	26	504
0.67	3	8	38	1072
0.71	3	11	64	2807
0.75	4	16	123	$1.0 * 10^4$
0.79	5	27	309	$5.7 * 10^4$
0.83	8	59	1191	$7.6 * 10^5$
0.87	16	207	$1.0 * 10^4$	$4.9 * 10^7$
0.91	53	2212	$6.4 * 10^5$	$1.2 * 10^{11}$
0.95	1253	$1.0 * 10^6$	$2.8 * 10^{10}$	$1.0 * 10^{20}$

Table 5.2: Critical legislature sizes for the dividing-the-pie setting

Section 5.5: Determining the critical legislature size in the endogenous budget setting, we use the Newton iteration method (10-digit precision) to solve the strict equality of

$$\frac{\delta - \delta^n}{1 - \delta^n} - 1 + \frac{1}{2\sqrt{n}} + \frac{1}{2n} \geq 0 \tag{5.57}$$

for $n \geq 2$. The rows 2 and 4 of table 5.3 show values of $\hat{n}$ for selected values of δ. A $(-)$ indicates that there exists no admissible $\hat{n}$ for the respective values of δ.

$\boldsymbol{\delta}$	< 0.66	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81
$\hat{\mathbf{n}}$	–	2	3	3	4	5	6	7	9
$\boldsymbol{\delta}$	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99
$\hat{\mathbf{n}}$	11	15	19	27	39	63	119	310	2600

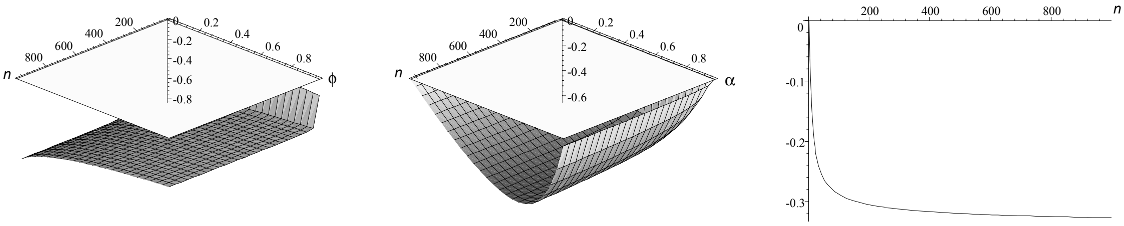
Table 5.3: Critical legislature sizes for the endogenous budget setting

5.A.4 Non-existence of $\hat{n}$

Claim 16 *If cooperation cannot be sustained for $n = 2$, it cannot be sustained for $n > 2$, either.*

<table>
<tr><td colspan="3">Claim 16 applies to sections 5.3 - 5.5 as, according to condition</td></tr>
<tr><td>(5.55),</td><td>(5.56),</td><td>(5.57),</td></tr>
<tr><td colspan="3">cooperation cannot be sustained if $\frac{\delta-\delta^n}{1-\delta^n} <$</td></tr>
<tr><td>$\frac{\ln\frac{n}{1+(n-1)\phi}}{\ln\frac{1}{\phi}}$.</td><td>$1-(1/n)^{1-\alpha}$.</td><td>$1-\frac{1}{2\sqrt{n}}-\frac{1}{2n}$.</td></tr>
<tr><td colspan="3">Hence, cooperation cannot be sustained for $n = 2$ if $\frac{\delta}{1+\delta} <$</td></tr>
<tr><td>$\frac{\ln\frac{2}{1+\phi}}{\ln\frac{1}{\phi}}$.</td><td>$1-(1/2)^{1-\alpha}$.</td><td>$\frac{3-\sqrt{2}}{4}$.</td></tr>
<tr><td colspan="3">Claim 16 then holds if, for</td></tr>
<tr><td>$\delta < \frac{\ln\frac{2}{1+\phi}}{\ln\frac{1+\phi}{2\phi}} =: \delta_1$,</td><td>$\delta < 2^{1-\alpha}-1 =: \delta_2$,</td><td>$\delta < \frac{3-\sqrt{2}}{1+\sqrt{2}} =: \delta_3$,</td></tr>
<tr><td colspan="3">condition</td></tr>
<tr><td>(5.55)</td><td>(5.56)</td><td>(5.57)</td></tr>
<tr><td colspan="3">is likewise violated for</td></tr>
<tr><td>$n > 2$ and all ϕ.</td><td>$n > 2$ and all α.</td><td>$n > 2$.</td></tr>
<tr><td colspan="3">As condition</td></tr>
<tr><td>(5.55)</td><td>(5.56)</td><td>(5.57)</td></tr>
<tr><td colspan="3">is most likely satisfied for large δs (see lemma 10), consider $\lim_{\delta\to\delta_i}\frac{\delta-\delta^n}{1-\delta^n} =$</td></tr>
<tr><td>$\frac{\frac{\ln\frac{2}{1+\phi}}{\ln\frac{1}{\phi}}-\left(\frac{\ln\frac{2}{1+\phi}}{\ln\frac{1}{\phi}}\right)^n}{1-\left(\frac{\ln\frac{2}{1+\phi}}{\ln\frac{1}{\phi}}\right)^n}$.</td><td>$1+\frac{2^{1-\alpha}-2}{1-(2^{1-\alpha}-1)^n}$.</td><td>$1+\frac{4\sqrt{2}-6}{1-\left(4\sqrt{2}-5\right)^n}$.</td></tr>
<tr><td colspan="3">Figure 5.4 depicts the strict equality of condition</td></tr>
<tr><td>(5.55)</td><td>(5.56)</td><td>(5.57)</td></tr>
<tr><td colspan="3">for the respective limit-value of $\frac{\delta-\delta^n}{1-\delta^n}$ as well as for</td></tr>
<tr><td>$n \le 10^3$ and $0 < \alpha < 1$.</td><td>$n \le 10^3$.</td><td>$n \le 10^3$ and $0 < \phi < 1$.</td></tr>
</table>

Figure 5.4: No cooperation



(a) Spillover (b) Dividing-the-pie (c) Endogenous budget

As the respective functions are negative, claim 16 holds for all 3 settings.

5.A.5 Derivation of g^a and $g^{\neg a}$ in the Endogenous Budget Setting

Recall that the Lagrange-program in (5.37) was stated as

$$\max_{g^a, g^{\neg a}} \; L = 2\beta\sqrt{g^a} - \frac{p}{n}\left[g^a + (n-1)\, g^{\neg a}\right] + \lambda \left\{2\beta\sqrt{g^{\neg a}} - \frac{p}{n}\left[g^a + (n-1)\, g^{\neg a}\right]\right\}$$

The first-order conditions for this program read as

$$\frac{\partial L}{\partial g^a} = \frac{\beta}{\sqrt{g_a}} - (1+\lambda)\frac{p}{n} = 0, \tag{5.58}$$

$$\frac{\partial L}{\partial g^{\neg a}} = \lambda \frac{\beta}{\sqrt{g^{\neg a}}} - (1+\lambda)\frac{p}{n}(n-1) = 0, \text{ and} \tag{5.59}$$

$$\frac{\partial L}{\partial \lambda} = 2\beta\sqrt{g^{\neg a}} - \frac{p}{n}\left[g^a + (n-1)\, g^{\neg a}\right] = 0. \tag{5.60}$$

Dividing (5.59) by (5.58) and eliminating the Lagrange-multiplier yields

$$\frac{\beta}{\sqrt{g^a}} = \left(1 + \frac{(n-1)\sqrt{g^{\neg a}}}{\sqrt{g^a}}\right)\frac{p}{n} \Leftrightarrow g^a = \left[\frac{n\beta}{p} - (n-1)\sqrt{g^{\neg a}}\right]^2 \tag{5.61}$$

Substitution into (5.60) yields

$$
\begin{aligned}
& 2\beta\sqrt{g^{\neg a}} = \frac{p}{n}\left\{\left[\frac{n\beta}{p} - (n-1)\sqrt{g^{\neg a}}\right]^2 + (n-1)\,g^{\neg a}\right\} \qquad (5.62)\\
\Leftrightarrow\quad & (n-1)\,ng^{\neg a} - \left(\frac{2n\beta\,(n-1)}{p} + \frac{2n\beta}{p}\right)\sqrt{g^{\neg a}} = -\frac{n^2\beta^2}{p^2} \Leftrightarrow g^{\neg a} = \left[\frac{(n\pm\sqrt{n})\,\beta}{(n-1)\,p}\right]^2.
\end{aligned}
$$

In equilibrium, an agenda setter proposes the lowest possible quantities for remaining regions, i.e.

$$
g^{\neg a} = \left[\frac{(n-\sqrt{n})\,\beta}{(n-1)\,p}\right]^2 = \left[\frac{\sqrt{n}\,(\sqrt{n}-1)\,\beta}{(\sqrt{n}+1)\,(\sqrt{n}-1)\,p}\right]^2 = \frac{n\beta^2}{\left(\sqrt{n}+1\right)^2 p^2}. \qquad (5.63)
$$

Re-insertion into (5.61) yields

$$
g^{a} = \left[\frac{n\beta}{p} - (n-1)\,\frac{\sqrt{n}\beta}{(\sqrt{n}+1)\,p}\right]^2 = \frac{n\beta^2}{p^2}. \qquad (5.64)
$$

Finally, inserting (5.64) and (5.63) into (5.30), payoffs for the agenda setter amount to

$$
\begin{aligned}
\pi^{a} &= 2\beta\sqrt{\frac{n\beta^2}{p^2}} - \frac{p}{n}\left[\frac{n\beta^2}{p^2} + (n-1)\,\frac{n\beta^2}{\left(\sqrt{n}+1\right)^2 p^2}\right] \qquad (5.65)\\
&= \frac{\beta^2}{p}\left[2\sqrt{n} - 1 - \frac{\sqrt{n}-1}{\sqrt{n}+1}\right] = \frac{2n}{\sqrt{n}+1}\,\frac{\beta^2}{p}
\end{aligned}
$$

whereas representatives from remaining regions receive

$$
\begin{aligned}
\pi^{a} &= 2\beta\sqrt{\frac{n\beta^2}{\left(\sqrt{n}+1\right)^2 p^2}} - \frac{p}{n}\left[\frac{n\beta^2}{p^2} + (n-1)\,\frac{n\beta^2}{\left(\sqrt{n}+1\right)^2 p^2}\right] \qquad (5.66)\\
&= \frac{\beta^2}{p}\left[\frac{2\sqrt{n}}{\sqrt{n}+1} - 1 - \frac{\sqrt{n}-1}{\sqrt{n}+1}\right] = 0.
\end{aligned}
$$

6. Strategy-contingent Reappointment

6.1 Introduction Chapter 6

Following the standard literature on repeated games, we have hitherto considered an agent's discounting parameter exogenous. In standard repeated games with infinitely-lived agents perpetually playing the same stage games, this view has prevailed for a simple reason. An agent's degree of patience is certainly an idiosyncratic characteristic and is, therefore, not subject to parameters of the respective game.

A standard result for games with exogenous discounting and infinitely-lived agents shows a positive correlation between the agents' degree of patience, as measured by the discount parameter δ, and the likeliness to sustain cooperation.[84] Well-known folk theorems, for example the exposition of the classical folk theorem in Fudenberg and Maskin (1986), put forward that if agents put sufficient weight on future payoffs, co-operation can be maintained by employing strategies that effectively punish deviation.

In a complementary approach, Abreu, Milgrom and Pearce (1991) show that reducing the interval between two consecutive stage games, i.e. between agents' interactions, has the same positive effect on the ability to maintain cooperation as increasing the exogenous discount parameter.[85] Intuitively, agents are more likely to resist the temptation to defect if there is prompt reward for cooperation. In this line, Neilson and Winter (1996) show that agents may even be able to sustain cooperation by deciding on appropriate interaction intervals.

[84] See, e.g. lemma 10.

[85] The authors go on to show that this equivalence does not necessarily hold in games with imperfect monitoring.

We argue that taking an agent's degree of patience as exogenous is an appropriate way of capturing discounting in repeated games with outcome-motivated agents. Yet, the degree of patience is no longer exogenous in case agents are rather office-motivated. Our argument follows the idea that a political decision maker is reappointed for another term in office iff her voters are prone to prolong her incumbency. Under a democratic regime, the latter circumstance is closely related to the degree of satisfaction voters associate with the incumbent's performance.[86] Accordingly, the degree of discounting in the sense of 'continuing the game' may depend on the agents' strategy choices, turning discounting into an endogenous determinant of cooperation. The purpose for this chapter is, therefore, to develop a framework that introduces endogenous discounting in the sense that the likeliness to reach the next stage of the repeated game varies in actual strategy choices.

As an inspiration for our analysis, Axelrod (1984) cites a halving of the fluctuation ratio within the US Congress in the course of the 20th century. Pointing to the fact that many political decisions show the structure of a *prisoner's dilemma*, he acclaims this development by stating that "*[t]he very possibility of achieving stable mutual co-operation depends upon there being a good chance of a continuing interaction*" (p. 16). We, rather literally, interpret this argument in a way that the probability of interacting *at all* in the future may be crucial for cooperation.

Our below framework endogenizes the latter probability by allowing for strategy-contingent reappointment. In this chapter, we assume that agents are office-motivated and actually face a prisoner's dilemma situation, such as a voluntary contribution game. As a major result, our framework shows that cooperation is possible if agents are quite optimistic about interacting again in the future. On the other hand, an agent may be tempted to pursue short-run interests in case she faces generally low chances of reap-

[86] By a similar argument, a company's decision maker may be dismissed if her company fails to meet certain profit yardsticks imposed by shareholders. In this case, she may actually choose strategies in a way to foster the renewal of her employment contract.

pointment because defection may promise to be her only chance of being reappointed at least once. Anticipating this incentive, other agents pursue inefficient short-run strategies, too, as they are reluctant to unilaterally harm their chances for another term in office. We essentially suggest that in a framework with office-motivated agents, strategy choices and discounting rather affect one another. Referring to the above Axelrod quote, we show that cooperation is in fact likely to emerge from small fluctuation ratios, i.e. from a high probability of interacting again in the next term.[87]

The remainder of this chapter[88] is organized as follows. Section 6.2 introduces the concept of strategy-contingent discounting in a general prisoner's dilemma framework with office-motivated agents. In the one-shot setting of subsection 6.2.1, agents are restricted to one reappointment at most. Subsection 6.2.2 relaxes the latter restriction and analyzes the necessary condition for sustaining cooperation in the repeated game. Sections 6.3 and 6.4 apply the general framework to the voluntary contribution game of subsection 4.3.1 and to a standard Cournot duopol, respectively. Section 6.5 concludes.

6.2 Basic Model

6.2.1 Static Setting

Before we get into details of the general model, we shall first lay out a brief structure. Although there is strategic interaction only at one point, we lay out the stage game in three steps. Consider a game that is played among two office-motivated agents $i = 1, 2$. At point 0, agents simultaneously choose their respective strategies in a way that fosters their chances for another term in office. At point 1, agents are reappointed for another term in office and receive a respective benefit if the outcome that results from their strategy choices meets a certain reappointment yardstick. Due to specific outcome shocks occurring at point 1/2, information is noised with regard to the actual strategies

[87] Fluctuation per se does not occur in standard repeated games as agents are modelled infinitely-lived and, in particular, infinitely-acting.

[88] Parts of this chapter are based on Koppel (2004c).

implemented at point 0. Hence, reappointment can merely be made contingent on realized outcome. This structure is summarized in figure 6.1.

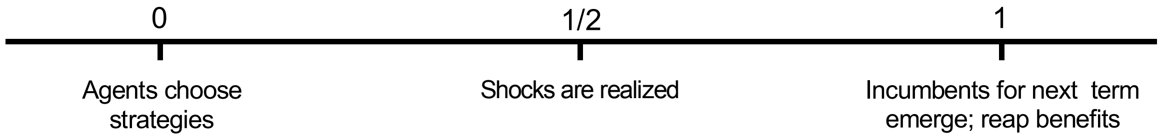


Figure 6.1: Game structure (one-shot)

The time span in this figure comprises one period. The details of the intraperiod process are as follows.

At point 0, agents simultaneously choose their strategies s_i from respective strategy sets $\{C, D\}$. Strategy choices result in outcomes $\rho_i(s_i, s_{-i})$. These outcomes are assumed to be ranked by

$$\rho_i^d := \rho_i(D, C) > \rho_i^* =: \rho_i(C, C) > \rho_i^e := \rho_i(D, D) > \rho_i^b := \rho_i(C, D). \tag{6.1}$$

In a standard prisoner's dilemma, a) ρ_i^d, b) ρ_i^*, c) ρ_i^e, and d) ρ_i^b immediately represent payoffs for agent i in case a) agent i defects whereas agent $-i$ cooperates, b) both agents cooperate, c) both agents defect (the standard prisoner's dilemma stage game equilibrium), and d) agent i cooperates whereas agent $-i$ defects. In our model, agent i is, though, rather interested in reappointment and faces a reappointment probability P_i that essentially depends on ρ_i (see below for details on P_i).

At point 1, agent i is reappointed iff the outcome ρ_i, net of a specific and additive shock $\tilde{\varepsilon}_i$, exceeds an exogenous reappointment yardstick $\bar{\rho}_i$.[89] Hence, reappointment ensues iff

[89]In the upcoming sections, these shocks represent utility shocks (section 6.3) and profit shocks (section 6.4), respectively.

$$\rho_i - \tilde{\varepsilon}_i \geq \bar{\rho}_i \tag{6.2}$$

holds.[90] Reappointed for another term in office, agents obtain a fixed benefit r whereas their payoffs are normalized to 0 in case they are dismissed from office. These benefits can either be interpreted as material benefits, such as actual rents (e.g. Buchanan (1980)), or as ego-rents (e.g. Persson and Tabellini (1999)), i.e. immaterial spoils associated with filling a certain position. We shall stick to the latter interpretation as it allows us to ignore additional financing constraints.

The shocks $\tilde{\varepsilon}_i$ are assumed to be distributed uniformly with density

$$f = \frac{1}{\theta_h - \theta_l} \tag{6.3}$$

on support $[\theta_l, \theta_h]$.[91] Accordingly, an agent's probability of reappointment P_i is just equal to the cumulative distribution of $\tilde{\varepsilon}_i$ evaluated at $\rho_i - \bar{\rho}_i$, yielding

$$P_i = \min \left\{ \max \left\{ \frac{\rho_i - \bar{\rho}_i - \theta_l}{\theta_h - \theta_l}, 0 \right\}, 1 \right\}. \tag{6.4}$$

We assume that agents are risk-neutral. Hence, they choose strategies in a way to maximize the expected benefits from office. The interval of $\bar{\rho}_i$ is restricted to

$$\bar{\rho}_i^{\min} := \rho_i^* - \theta_h < \bar{\rho}_i < \rho_i^e - \theta_l =: \bar{\rho}_i^{\max}. \tag{6.5}$$

[90] Seabright (1996) introduces such a re-election apparatus for office-motivated politicians. In his model, a_i and $\bar{a}_i$ represent the constituency's utility and the utility the constituency associates with a rival contender, respectively. Contrasting our framework, the approach in Seabright (1996) does not comprise strategical interaction.

[91] See, e.g. Mood, Graybill and Boes (1974), pp. 105-107, for an introduction to the uniform distribution.

These restrictions ensure a positive reappointment probability in the stage game equilibrium and, furthermore, preserve the prisoner's dilemma structure by yielding proper incentives to deviate from cooperation in the one-shot game.[92] For $\bar{\rho}_i \leq \bar{\rho}_i^{\min}$, an agent might be reappointed with probability 1 even if she was confronted with the shock's 'worst-case' realization θ_h. In this case, playing the cooperative strategies might likewise constitute a stage game Nash-equilibrium. On the other hand, for $\bar{\rho}_i \geq \bar{\rho}_i^{\max}$, an agent might be dismissed from office even if she faced the 'best-case' realization θ_l. As we shall be concerned with repeated interaction in the next section, we rule out the latter situation and assume that choosing strategy D always yields a positive reappointment probability.

Following the notion of outcomes in (6.1), let P_i^* denote an agent's reappointment probability in case both representatives adhere to cooperation. Unilateral defection by agent i increases her reappointment probability to P_i^d. Furthermore, let P_i^e and P_i^b denote the stage game equilibrium reappointment probability and the reappointment probability in case a cooperating agent is 'betrayed' by her counterpart. The resulting payoff structure for the stage game is summarized in table 6.1. Following the standard presentation of PD-games[93], agent 1 is the row-player, and agent 2 acts as the column-player.

	C	D
C	$P_1^* r, P_2^* r$	$P_1^b r, P_2^d r$
D	$P_1^d r, P_2^b r$	$P_1^e r, P_2^e r$

Table 6.1: Expected benefits in the prisoner's dilemma stage game

Given the ranking of outcomes in (6.1) as well as the restrictions in (6.5), we have

[92] For low reappointment yardsticks, the restrictions in (6.5) do not rule out that agents can secure reappointment ($P_i^d = 1$) by defecting successfully.

[93] See, e.g. Varian (1992), pp. 261-262.

$$1 \geq P_i^d > P_i^* > P_i^e > P_i^b. \tag{6.6}$$

The ranking in (6.6) implies that (i) (D, D) is always the stage game equilibrium and (ii) (D, D) is Pareto-inferior to (C, C). Due to the stage game structure, (C, C) can, though, never constitute an equilibrium of the one-shot game. Following the logic of the previous chapters, we shall now extend the game's horizon and derive a necessary condition for sustaining cooperation in a repeated game.

6.2.2 Repeated Setting

In the repeated game, the basic stage game of subsection 6.2.1 is played over an infinite horizon. Yet, agents are due to be reappointed at the end of each period. This feature implies that specific agents *potentially* interact over several periods.[94] Like in the previous chapters, we assume perfect recall. Agents in period t can, therefore, choose their actions contingent on the game's history h_t. The former will consider the impact of their current actions on their current and future reappointment probabilities.

Recall that, in the stage game, both agents do better under a regime of mutual cooperation. As was argued in previous chapters, the well-known trigger-strategy may resolve these inefficiencies in repeated prisoner's dilemma games. We extend the genuine trigger-strategy (Friedman (1971)) by an index t in order to allow for fluctuation among agents in the course of the repeated game. The corresponding trigger-strategy for an agent in period t is characterized by

[94] Exemplifying this point, a 'lucky'/'unlucky' agent may be dismissed after her tenth/first term in office. Anyway, an agent is certain to be dismissed from office at *some* stage of the repeated game. As apparent from the below analysis, this is due to the fact that her average probability of reappointment is strictly smaller than unity.

$$s_{it} = \begin{cases} C & \text{if } t = 1 \\ C & \text{if } t > 1 \ \wedge \ h_t = \left\{ (C,C)_1, \ldots, (C,C)_{t-1} \right\} \\ D & \text{else} \end{cases} \qquad . \tag{6.7}$$

Employing these strategies, agents choose to cooperate in the repeated game's first period. Agents appointed for subsequent periods, possibly replacing their predecessors, choose to cooperate if all agents cooperated in all previous periods. Otherwise, there is infinite Nash-reversion, and agents play the stage game equilibrium from that point on. A dismissal from office is normalized to entail no further payoffs in subsequent periods.

Let us address the necessary condition for maintaining cooperation in the repeated game. If both agents cooperate, they are reappointed with the respective probability P_i^* at the end of each term. The discounted payoffs, in terms of expected benefits, from mutual cooperation then read as[95]

$$\Pi_i^* = \frac{P_i^*}{1 - P_i^*} r. \tag{6.8}$$

In case of a defection from cooperation, the defecting agent is reappointed with probability P_i^d at the end of the period of defection. Yet, she triggers Nash-reversion and is, therefore, merely reappointed with probability P_i^e at the end of subsequent periods.[96] Accordingly, defection yields expected benefits

$$\Pi_i^d = \frac{P_i^d}{1 - P_i^e} r. \tag{6.9}$$

The strategies in (6.7) constitute a subgame perfect equilibrium of the repeated game if

[95] The algebra is relegated to appendix 6.A.1.

[96] As in standard repeated games, any defection will be carried out in the first period. See appendix 6.A.2 for the corresponding proof.

the expected benefits from cooperation outweigh benefits from defection. The necessary condition for maintaining cooperation in the repeated game can, therefore, be expressed as

$$\frac{1-P_i^e}{1-P_i^*} \geq \frac{P_i^d}{P_i^*}. \tag{6.10}$$

The RHS of (6.10) measures the short-term gain from defection, i.e. the one-time increase of reappointment probability from P_i^* to P_i^d. In order to maintain cooperation, this gain must not surpass the long-term costs from defection. These costs are captured by the LHS of (6.10) and measured by the permanent increase of dismissal probability from $1 - P_i^*$ to $1 - P_i^e$ in periods subsequent to defection. According to condition (6.10), the case for cooperation depends on the agents' estimation of their respective strategy-contingent reappointment probabilities.

What drives the ability to maintain cooperation?

Proposition 17 *Cooperation (i) can be sustained for mutually small reappointment yardsticks. (ii) The ability to maintain cooperation decreases in reappointment yardsticks.*

Proof. (i) Recall (6.4) and (6.6). Inspection reveals that $\lim_{\bar{\rho}_i \to \bar{\rho}_i^{\min}} \text{LHS } (6.10) = \infty$ whereas $\lim_{\bar{\rho}_i \to \bar{\rho}_i^{\min}} \text{RHS } (6.10) = 1$. As P_i^* converges to 1, there are infinite costs from defection whereas the gain from defection vanishes. (ii) Observe that $\frac{\partial \text{LHS } (6.10)}{\partial \bar{\rho}_i} < 0$ and $\frac{\partial \text{RHS } (6.10)}{\partial \bar{\rho}_i} > 0$, i.e. the costs (gain) from defection decrease (increases) in $\bar{\rho}_i$. Both facts render defection more attractive. ■

There is an appealing intuition underlying the results in proposition 17. In case of low reappointment yardsticks, there is not much of a gain from defection. The reason is that, cooperating or defecting, an agent is rather certain to be reappointed anyway. On the other hand, the marginal extra benefit gained from defection comes at the expense of (severely) jeopardizing further reappointments.

Increasing the reappointment yardstick, all three strategy-contingent reappointment probabilities decrease by the same absolute amount. Yet, as both the gain and costs from defection are measured in relative terms, part (ii) of proposition arises. For high reappointment yardsticks, P_i^e converges to 0, i.e. an agent is rather certain to be dismissed in the stage game equilibrium. According to (6.10), cooperation is then still sustainable if $P_i^d P_i^* \geq P_i^d - P_i^*$ holds for $\bar{\rho}_i \rightarrow \bar{\rho}_i^{\max}$. Otherwise, there exists a critical value $\bar{\rho}_i^+$ in a way that cooperation breaks down for $\bar{\rho}_i > \bar{\rho}_i^+$.

We derived the above results for a general prisoner's dilemma structure. The next two sections exemplify the results in proposition 17 for typical dilemma games.

6.3 Decentralized Public Good Provision

6.3.1 Stage Game

This example follows the presentation of the basic model, as laid out in section 6.2. In the current scenario, we come back to the asymmetric game of voluntary public good provision, as presented in subsection 4.3.1. The difference is that regional politicians are now office-motivated, i.e. they choose regional public good quantities to foster their chances for another term in office. Adapting the notation, quantities g_i now refer to strategy choices s_i, and regional public good surplus S_{iD} refers to outcome ρ_i.

At the end of the legislative period, a regional incumbent is re-elected if the surplus S_{iD} in that region, net of a region-specific utility shock $\tilde{\varepsilon}_i$, exceeds an exogenous reappointment yardstick $\bar{S}_{iD}$. Following Seabright (1996), we interpret $\bar{S}_{iD}$ as the surplus regional voters expect from a rival party. Hence, a politician in region i is re-elected iff

$$S_{iD} - \tilde{\varepsilon}_i \geq \bar{S}_{iD} \tag{6.11}$$

holds. For an incumbent, the shock $\tilde{\varepsilon}_i$ implies that her voters cannot appropriately link realized surpluses to actual contribution choices $\{g_1, g_2\}$. Following (6.4), an incumbent's probability of re-election is now just equal to

$$P_i = \min \left\{ \max \left\{ \frac{S_i - \bar{S}_i - \theta_l}{\theta_h - \theta_l}, 0 \right\}, 1 \right\}. \tag{6.12}$$

For a possible interpretation, think of θ as a measure of quality associated with the rival party's leader. Values of θ close to θ_l (θ_h) then imply that regional voters perceive the contender as fairly weak (strong) with this fact improving (worsening) the incumbent's chances of re-election.

As the strategy set in the voluntary contribution game of subsection 4.3.1 is continuous, we allow for continuous non-negative contribution levels in the current example as well.[97] Hence, the stage game Nash-equilibrium is characterized by

$$g_i^e = \arg\max_{g_i \geq 0} \; P_i \left(g_i, g_{-i}^e \right) r. \tag{6.13}$$

Following the reasoning presented for condition (6.5), the interval of regional reservation surplus $\bar{S}_i$ is restricted to

$$\bar{S}_{iD}^{\min} := S_{iD}^* - \theta_h < \bar{S}_{iD} < S_{iD}^e - \theta_l =: \bar{S}_{iD}^{\max}. \tag{6.14}$$

In this regard, S_{iD}^* and S_{iD}^e denote the cooperative regional public good surpluses (4.2) and the stage game equilibrium surpluses (4.9), respectively. Given these restrictions, the first-order conditions emerging from (6.13) read as

$$f \left(S_{iD} - \bar{S}_{iD} \right) \frac{\partial S_{iD}}{\partial g_i} r = 0. \tag{6.15}$$

[97] As illustrated below, allowing for continuous strategy spaces does not alter the payoff relation.

In this condition, $f\left(S_{iD} - \bar{S}_{iD}\right)$ is simply the density of the shock evaluated at $S_{iD} - \bar{S}_{iD}$. Accordingly, politicians choose their region's contribution to the public good in a way that the marginal re-election benefit, in terms of additional re-election probability multiplied by the marginal increase of their region's utility multiplied by the benefit from holding office, equals 0.

Note that the first and third factor on the LHS of (6.15) are constants. Hence, the first-order conditions reduce to $\frac{\partial S_{iD}}{\partial g_i} = 0$, yielding the very same reaction functions and stage game equilibrium quantities as in (4.7) and (4.8), respectively. From (4.16), (4.20), and (4.21), recall that $S_{iD}^d > S_{iD}^* > S_{iD}^e$. For both politicians, this fact implies that the stage game equilibrium re-election probabilities P_i^e are inefficiently small compared to the cooperative re-election probabilities P_i^*.

6.3.2 Repeated Game and Numerical Example

Resolving the inefficiencies induced by the stage game dilemma now requires that representatives abstain from (partially) withdrawing their cooperative public good contributions. The trigger-strategy for an incumbent from region i in period t is, therefore, characterized by

$$g_{it} = \begin{cases} g_i^* & \text{if } t = 1 \\ g_i^* & \text{if } t > 1 \ \wedge \ h_t = \left\{(g_1^*, g_2^*)_1, \ldots, (g_1^*, g_2^*)_{t-1}\right\} \\ g_i^e & \text{else} \end{cases} . \tag{6.16}$$

Following the familiar notion, g_i^* and g_i^e denote the cooperative quantities (4.15) and stage game equilibrium quantities (4.8), respectively.

Let us illustrate the results in proposition 17 for specified parameters. We assign values

$$\sigma = 0.5, \ \beta = 10, \ p = 1, \ \theta_l = 0, \text{ and } \theta_h = 5. \tag{6.17}$$

Insertion into (4.16), (4.20), (4.21), and (6.14) then yields the surplus measures depicted in table 6.2.

Region 1	Region 2
$S_{1D}^{*} = 13.75$	$S_{2D}^{*} = 11.87$
$S_{1D}^{d} = 14.70$	$S_{2D}^{d} = 12.95$
$S_{1D}^{e} = 13.03$	$S_{2D}^{e} = 11.51$
$\bar{S}_{1}^{\min} = 8.75$	$\bar{S}_{2}^{\min} = 6.87$
$\bar{S}_{1}^{\max} = 13.03$	$\bar{S}_{2}^{\max} = 11.51$

Table 6.2: Regional surplus measures

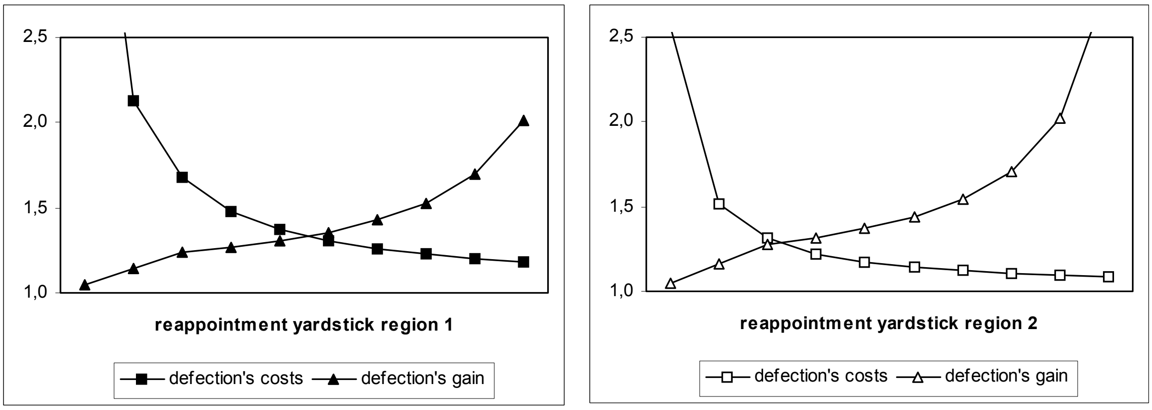
Recall that proposition 17 is based on the impact of reappointment yardsticks on the strategy-contingent reappointment probabilities. Columns 1 and 7 of table 6.3, therefore, start in the neighborhood of $\bar{S}_{i}^{\min}$ and increase the region-specific reappointment yardstick by $\frac{1}{10}\left(\bar{S}_{i}^{\max} - \bar{S}_{i}^{\min}\right)$ at a time. Inserting these values of $\bar{S}_{i}$, the parameter specifications according to (6.17), and the surplus measures of table 6.2 into (6.12) yields the strategy-contingent reappointment probabilities, as depicted in columns $2-4$ and $8-10$. Finally, columns $5-6$ and $11-12$ present the respective LHS- and RHS-values of condition (6.10).

$\bar{S}_1$	P_1^{*}	P_1^{e}	P_1^{d}	LHS_1	RHS_1	$\bar{S}_2$	P_2^{*}	P_2^{e}	P_2^{d}	LHS_2	RHS_2
9.0	0.96	0.81	1.00	4.37	1.04	7.1	0.95	0.88	1.00	2.55	1.05
9.4	0.87	0.73	1.00	2.12	1.15	7.6	0.86	0.79	1,00	1.52	1.16
9.8	0.79	0.64	0.98	1.67	1.24	8.0	0.77	0.70	0.98	1.31	1.28
10.2	0.70	0.56	0.89	1.48	1.27	8.5	0.68	0.60	0.89	1.22	1.32
10.7	0.61	0.47	0.80	1.37	1.31	9.0	0.58	0.51	0.80	1.17	1.37
11.1	0.53	0.39	0.72	1.31	1.36	9.4	0.49	0.42	0.71	1.14	1.44
11.5	0.44	0.30	0.63	1.26	1.43	9.9	0.40	0.32	0.61	1.12	1.54
12.0	0.36	0.21	0.55	1.22	1.53	10.4	0.30	0.23	0.52	1.10	1.71
12.4	0.27	0.13	0.46	1.20	1.69	10.8	0.21	0.14	0.43	1.09	2.02
12.8	0.19	0.04	0.38	1.18	2.01	11.3	0.12	0.05	0.33	1.08	2.82

Table 6.3: Impact of the reappointment yardstick in the voluntary contribution game

Figure 6.2 depicts the columns $5-6$ and $11-12$ of table 6.3, i.e. the respective costs and gain from defection. Illustrating part (i) of proposition 17, this figure shows that cooperation can be sustained for mutually small reappointment yardsticks as the costs from defection surpass the gain from defection in this case. Yet, the respective costs (gain) from defection decrease (increases) in the reappointment yardstick, as laid out in part (ii) of proposition 17. In this example, there exists a region-specific critical reappointment yardstick $\bar{S}_i^+$ so that cooperation cannot be sustained for $\bar{S}_i > \bar{S}_i^+$.[98]

Figure 6.2: Defection's costs and gain in the public good example



(a) Incumbent region 1 (b) Incumbent region 2

In case of high yardsticks, cooperation now breaks down because of too little reward for long-term cooperation. Cooperating or defecting, an agent anticipates to be ejected soon anyway, and defection promises to be her only substantial chance to become reappointed at least once.

[98]Intuitively, the same quality of results emerges if we apply the present framework to the symmetric voluntary contribution game of subsection 3.3.2.

6.4 Cournot Duopol Example

For the present example, we build on a standard Cournot duopol with two companies, linear demand, and costless production.[99] This example follows exactly the structure developed in section 6.2 and exemplified in section 6.3. We therefore widely constrain the formal presentation.

Adapting the notation of the basic model, company-specific output quantities q_i now refer to strategy choices s_i and company profits μ_i refer to outcomes ρ_i. Companies face linear demand

$$p\left(q_1, q_2\right) = 1 - q_1 - q_2. \tag{6.18}$$

In our modification of the standard duopol game, a business manager – say a chief executive officer (CEO) – decides on her company's output quantity q_i. Again, we allow for continuous strategy spaces.

In order to stay in charge, CEOs are due to meet certain profit yardsticks, as denoted by $\bar{\mu}_i$. The yardstick $\bar{\mu}_i$ might represent a level of profit shareholders associate with another CEO-candidate. Let company profits be affected by specific demand shocks and shareholders make the renewal of employment contracts contingent on realized profits. Hence, a CEO chooses the output quantity q_i in a way to foster the renewal of her employment contract. Accordingly, the adapted version of the general reappointment condition (6.2) reads as

$$\mu_i - \tilde{\varepsilon}_i \geq \bar{\mu}_i. \tag{6.19}$$

For the standard Cournot duopol, the outcomes a) μ_i^*, b) μ_i^e, c) μ_i^d, and d) μ_i^b repre-

[99] We refer to a standard duopol game, as developed in Shy (1995), pp. 115-117. He explicitly derives all the below quantities and payoffs for an infinitely repeated duopol game. Referring to the above source, we, therefore, abstain from an explicit derivation of these measures.

sent profits for company i in case a) both companies share the monopoly quantity, b) produce the stage game equilibrium quantities, c) company i 'cheats' on the cooperating partner, and d) company i cooperates but is 'betrayed' by the other company, respectively.

In the cooperative situation, CEOs agree to collude, i.e. they choose identical output quantities $q^* = \frac{1}{4}$ in a way that their companies earn an equal share $\mu^* = \frac{1}{8}$ of the market's monopoly rent, respectively.[100] Yet, as CEOs cannot commit to output discipline in the one-shot setting, each of them faces an incentive to produce more output than in the cooperative situation. In the stage game Cournot-equilibrium, each company, therefore, rather produces output $q^e = \frac{1}{3}$ and earns profits $\mu^e = \frac{1}{9}$. A CEO defecting from cooperation expects her counterpart to choose $q^* = \frac{1}{4}$. Her best response is to set $q^d = \frac{3}{8}$, thus generating profits $\mu^d = \frac{9}{64}$ for her company. Adapting condition (6.5), profit yardsticks are restricted to

$$\bar{\mu}^{\min} := \mu^* - \theta_h < \bar{\mu}_i < \mu^e - \theta_l =: \bar{\mu}^{\max}. \tag{6.20}$$

In order to sustain collusion, CEOs now employ trigger-strategies

$$q_{it} = \begin{cases} \frac{1}{4} & \text{if } t = 1 \\ \frac{1}{4} & \text{if } t > 1 \ \wedge \ h_t = \left\{ (q^*, q^*)_1, \ldots, (q^*, q^*)_{t-1} \right\} \\ \frac{1}{3} & \text{else} \end{cases} \tag{6.21}$$

in the repeated game. Of course, all the formulae of section 6.2 have their adapted pendants in the duopol example. We shall, though, abstract from a detailed presentation and turn to a graphical analysis instead. Recall that we aim to illustrate the results in proposition 17.

[100] Due to the symmetry, we drop the index i.

For the numerical example, as laid out in table 6.4, we set θ_l to 0 and θ_h to 0.1. From (6.20), we then obtain $\bar{\mu}^{\min} = 0.025$ and $\bar{\mu}^{\max} = 0.111$. Following the reasoning introduced in the previous section, column 1 of table 6.4 starts in the neighborhood of $\bar{\mu}^{\min}$ and increases the reappointment yardstick by $\frac{1}{10}\left(\bar{\mu}^{\max} - \bar{\mu}^{\min}\right)$ at a time. Inserting these values of $\bar{\mu}$ as well as the above profit measures μ^*, μ^d, and μ^e into the adapted version of (6.4) yields the strategy-contingent reappointment probabilities. These probabilities are presented in columns $2-4$. Finally, columns 5 and 6 present the respective costs and gain from defection, as represented by the LHS and RHS of condition (6.10).

$\bar{\mu}$	P^*	P^d	P^e	LHS	RHS
0.029	0.91	1.00	0.78	2.61	1.09
0.038	0.83	0.98	0.69	1.81	1.19
0.047	0.74	0.90	0.60	1.54	1.21
0.055	0.66	0.81	0.52	1.40	1.24
0.064	0.57	0.73	0.43	1.32	1.27
0.072	0.48	0.64	0.34	1.27	1.32
0.081	0.40	0.55	0.26	1.23	1.39
0.090	0.31	0.47	0.17	1.20	1.50
0.098	0.27	0.13	0.42	1.19	1.58
0.107	0.18	0.34	0.04	1.17	1.86

Table 6.4: Impact of the reappointment yardstick in the Cournot duopol

The last two columns of table 6.4 are depicted in figure 6.3. Again, we find graphical support for proposition 17 as cooperation can be sustained for mutually small reappointment yardsticks whereas the gain (costs) from defection increases (decrease) in the reappointment yardstick. Like in the example of section 6.3, there exists a critical reappointment yardstick $\bar{\mu}^+$. This implies that cooperation cannot be sustained for $\bar{\mu}_i > \bar{\mu}^+$. The basic finding for this section is, therefore, that CEOs find it easier to implement tacit collusion if they are generally quite optimistic about meeting profit yardsticks, and thus being reappointed.

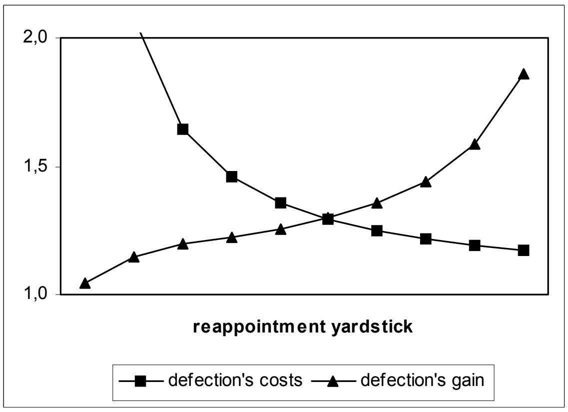


Figure 6.3: Defection's costs and gain in the duopol example

6.5 Conclusion Chapter 6

This chapter introduces a concept of endogenous discounting for repeated games. Discounting is endogenous in the sense that the likeliness to reach the next stage of the game depends on the agents' strategy choices. Agents face strategy-contingent reappointment probabilities and find it harder to implement cooperation with high reappointment yardsticks. On the other hand, cooperation can be sustained for low yardsticks. As the applications in sections 6.3 and 6.4 demonstrate, high reappointment yardsticks may impede cooperation. Hence, the endogenous degree of discounting proves to be yet another determinant for cooperative public good provision.

Our concept can be applied to various standard PD-games. Consider the free riding problem arising for decentralized public good provision, as laid out in section 6.3. If regional politicians choose voluntary contributions in a way to foster their re-election, tough political pressure, in terms of strong challengers running for incumbency, may inhibit efficient provision levels.[101] Alternatively, section 6.4 interprets the basic prob-

[101] Building on a similar conceptual framework, Koppel (2003) shows that substantial lobbying costs sustain cooperative outcomes in a dynamic perspective of centralized policy making. A preliminary version of that paper was presented at the conferences "Lobbying and Institutional Structure of Policy Making" (September, 26-27, 2002, Rome) and "METU International Conference in Economics VI"

lem as duopolistic rent absorption. If shareholders make the renewal of employment contracts contingent on realized profits, managers find it harder to implement tacit collusion in case they face high profit yardsticks.

Our findings support Axelrod's (1984) argument concerning the negative correlation between fluctuation ratios and cooperation, as laid out in the introduction to this chapter. In our framework, high reappointment probabilities go hand in hand with low incentives to deviate from cooperation. We argue that cooperative strategy patterns may emerge if agents are rewarded less – in terms of reappointment probability – for pressing home an advantage than for repeatedly settling things cooperatively.

We employ modified, yet in a way standard trigger-strategies. An appealing modification of this strategy might advise agents to punish deviants until the latter are ejected from office and negotiate a return to cooperation with their successors.

In our basic framework, agents receive the same benefit for reaching the next round of the repeated game whereas the respective likeliness is strategy-contingent. An extension of our basic model might consider strategy-contingent benefits from reaching the next stage, such as profit-contingent salaries for company managers. This type of benefits adds a reward term to condition (6.10) that might have some interesting implications for the ability to maintain cooperation.

(September, 11-14, 2002, Ankara).

6.A Appendix Chapter 6

6.A.1 Calculating Π_i^* and Π_i^d

Under a regime of mutual cooperation, an agent is reappointed with probability P_i^* at the end of each period. Her expected benefits from cooperation, therefore, amount to

$$\Pi_i^* = \left[P_i^* + (P_i^*)^2 + (P_i^*)^3 + \ldots\right] r = P_i^* \sum_{t=0}^{\infty} (P_i^*)^t \, r = \frac{P_i^*}{1 - P_i^*} r. \tag{6.22}$$

In case an agent defects in the first period of the repeated game, she is reappointed with probability P_i^d at the end of that period. Due to infinite Nash-reversion, she is, though, reappointed only with probability P_i^e at the end of subsequent periods. Her expected benefits from immediate defection, therefore, read as

$$\Pi_i^d = \left[P_i^d + P_i^d P_i^e + P_i^d (P_i^e)^2 + \ldots\right] r = P_i^d \sum_{t=0}^{\infty} (P_i^e)^t \, r = \frac{P_i^d}{1 - P_i^e} r. \tag{6.23}$$

6.A.2 Defecting Agents Prefer Immediate Defection

From (6.22) and (6.23), we have $\Pi_i^* = \frac{P_i^*}{1-P_i^*} r$ and $\Pi_i^d = \frac{P_i^d}{1-P_i^e} r$. Let $\Pi_i^{d,t}$ denote expected benefits from defection in period $t > 1$. We then have

$$\begin{aligned}
\Pi_i^{d,t} &= \left[P_i^* + \ldots + (P_i^*)^{t-1} + (P_i^*)^{t-1} P_i^d + (P_i^*)^{t-1} P_i^d P_i^e + \ldots\right] r \qquad (6.24)\\
&= \left[\sum_{t=1}^{t-1} (P_i^*)^t + (P_i^*)^{t-1} P_i^d \sum_{t=0}^{\infty} (P_i^e)^t\right] r \\
&= \left[\frac{P_i^* - (P_i^*)^t}{1 - P_i^*} + \frac{(P_i^*)^{t-1} P_i^d}{1 - P_i^e}\right] r.
\end{aligned}$$

Accordingly, the payoff difference between defection in period $t+1$ and defection in period t can be expressed as

$$\begin{aligned}\Pi_i^{d,t+1} - \Pi_i^{d,t} &= \left[\frac{P_i^* - \left(P_i^*\right)^{t+1}}{1-P_i^*} + \frac{\left(P_i^*\right)^t P_i^d}{1-P_i^e} - \frac{P_i^* - \left(P_i^*\right)^t}{1-P_i^*} - \frac{\left(P_i^*\right)^{t-1} P_i^d}{1-P_i^e}\right] r \quad (6.25)\\ &= \left[\frac{\left(P_i^*\right)^t - \left(P_i^*\right)^{t+1}}{1-P_i^*} - \frac{P_i^d\left(\left(P_i^*\right)^{t-1} - \left(P_i^*\right)^t\right)}{1-P_i^e}\right] r\\ &= \underbrace{\left[\left(P_i^*\right)^{t-1} - \left(P_i^*\right)^t\right]}_{>0} \underbrace{\left(\frac{P_i^*}{1-P_i^*} - \frac{P_i^d}{1-P_i^e}\right)}_{\Pi_i^* - \Pi_i^d} r.\end{aligned}$$

This equation shows that any defection will be carried out in the first period. If defection is not worthwhile in the first period, i.e. if $\Pi_i^* > \Pi_i^d$, it is not worthwhile in *any* subsequent period. If defection is worthwhile in the first period $\left(\Pi_i^* < \Pi_i^d\right)$, it is not *as* worthwhile in subsequent periods.

7. Conclusion

This thesis has introduced a dynamic perspective of fiscal federalism. Our analysis has compared the relative pros and cons of policy-making at a central and decentral layer of a federation in repeated game frameworks. In essence, we have analyzed the impact of public good spillovers (chapter 3), interregional preference heterogeneity (chapter 4), the number of federal member states (chapter 5), and reappointment yardsticks (chapter 6) on the regimes' ability to yield efficiency-sustaining cooperative public good provision. Building on the determinant-specific correlation, we were able to derive guidelines for assigning public good policies in a dynamic framework.

The repeated game analysis of fiscal federalism helps to explain cooperative public good provision at both the central and decentral layer of a federal system from a theoretical point of view. Our central results can be summarized as follows. In a dynamic perspective, an efficient allocation of local public good policies entailing significant (negligible) externalities on other regions is more likely sustainable at a decentral (central) layer. This finding implies a guideline for policy assignment that stands at odds with the prevailing opinion promoted by the existing static fiscal federalism literature in the tradition of Oates (1972). Our results are driven by the fact that, in a dynamic perspective of polic-making at the federal layer, a credible threat of future exclusion from legislative benefits may serve as a mechanism for inducing a cooperative distribution of benefits. Whereas such a threat is viable for public goods entailing locally concentrated benefits, the non-excludability characteristic of pure public goods impedes efficiency-sustaining cooperation among legislators.

Substantial interregional preference heterogeneity impedes efficient provision of pure public goods both at the federal and decentral layer. The reason is that low-preference regions can neither resist to opt for an inefficiently low level of public good provision at the federal layer nor overcome short-run incentives to free-ride under the decentralized regime. Rendering the stage game perspective relevant, there are only minor inefficiencies associated with underprovision under the decentralized regime in case of substantial heterogeneity, and the latter should be assigned the provision of pure public goods.

Our predominant result concerning public good provision at the federal layer can be summarized in a way that the repetition inherent in the political process along with volatility of political power may induce representatives to comply with a norm of efficiency-sustaining cooperative benefit distribution. At the federal layer, an efficient distribution of benefits is, though, supposed to be observed only in small legislatures, i.e. with a limited number of federal member states. Efficiency can be attained only for an ever smaller set of public good policies if the size of the federation is increased. Indeed, a critical number of federal member states can be shown to exist in a way that cooperation breaks down in the course of a further enlargement. Eventually, a centralized adminstration of public good policies proves to entail inefficiencies in large federations for all types of public goods. On the other hand, there are particularly viable prospects for attaining decentral cooperation in large federations.

Adding to the above determinants of cooperative public good provision, we finally developed the concept of strategy-contingent discounting in order to endogenize the very impact of repeated interaction on the ability to attain cooperative outcomes in repeated dilemma games. Applying the general framework to a fiscal federalism problem, our findings predict that office-motivated politicians are prone to pursue inefficient short-run interests when facing significant risks of a dismissal from office, as induced by tough political competition. Our results can be interpreted in way that cooperation is likely to emerge if politicians face good prospects of being reappointed for another term in office.

Generally speaking, our results challenge the estimation that unanimity voting at the federal layer necessarily entails a cooperative distribution of legislative benefits. Indeed, we show that there may rather result an utmost uncooperative allocation of legislative benefits even if the legislature employs a unanimity rule for policy adoption. Standard results of legislative policy-making (e.g. Bednar, Ferejohn and Garrett (1996), p. 283, proposition 1) exhibit a negative correlation between quorum size and agenda power. Hence, agenda power is utmost restricted under a unanimity rule, i.e. whenever an agenda setter is able to implement her favored policy under a unanimity rule, she can implement her favored policy under any lower quorum, too. This conclusion implies that our results of centralized decision-making immediately extend to various other rules like (qualified) majority voting.[102]

In the absence of legislative decision-making costs, the standard wisdom emerging from a static political economy analysis states that a reduction in quorum size increases the disparity of legislative benefits. At the expense of an increasing minority, benefits are predicted to be concentrated in a fewer number of regions. Our results rather indicate that, in a dynamic perspective, the increased risk of being excluded from legislative benefits under a majority rule may rather serve as an efficiency-sustaining element. Further research concerning the impact of legislative rules on the prospects for sustaining legislative cooperation in dynamic frameworks may, therefore, yield valuable insights.

Summarizing our repeated game analysis of fiscal federalism models, our findings certainly highlight the importance of considering dynamic aspects of policy-making for deriving feasible policy guidelines.

[102] See section 5.5 for an exception. In that section, adopting policies according to a majority rule furthermore biases the distribution of legislative benefits in favor of the agenda setter's region.

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