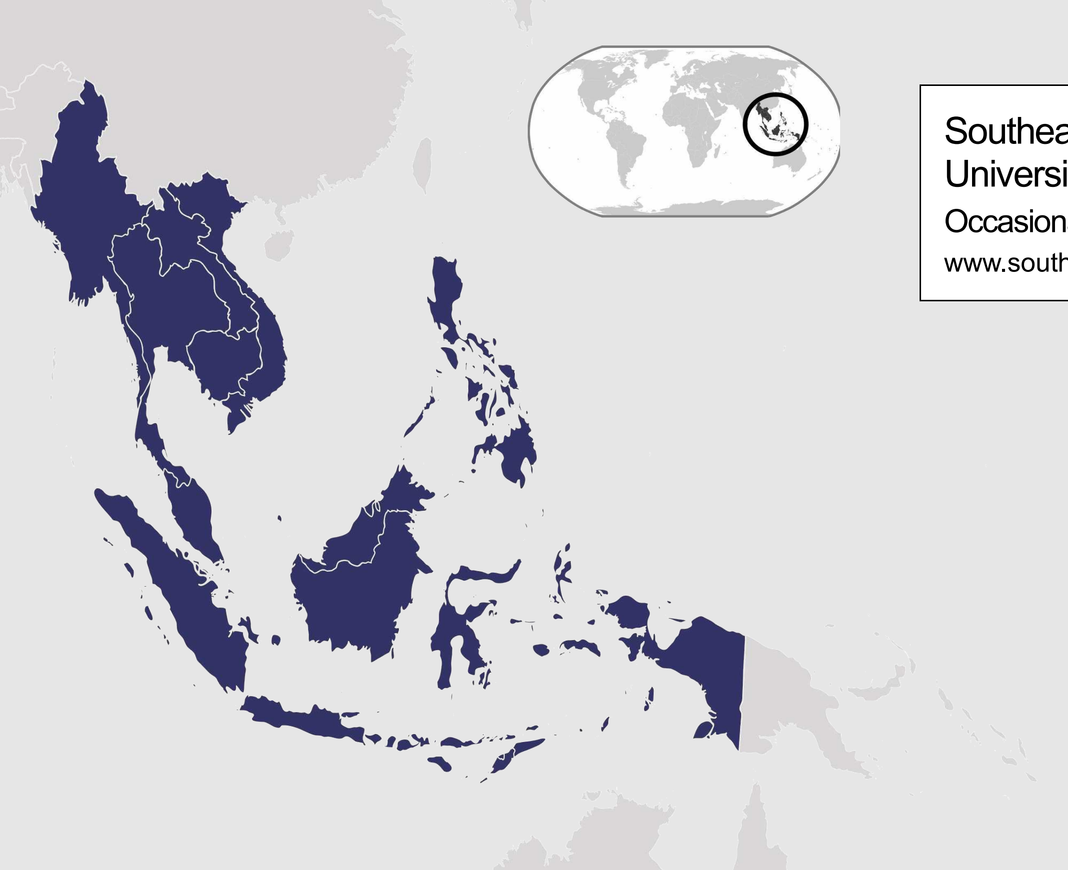

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Decentralization as Unbundling of Public Goods Provision

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Decentralization as Unbundling of Public Goods Provision

New Effects of Decentralization on Efficiency and Electoral Control*

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Abstract

This paper proposes a new perspective for studying decentralization by considering it as the unbundling of public goods provision. We define centralization as the bundled provision of public goods from different tiers (national, sub-national or local) by one single provider held accountable by the voters via elections. We define decentralization as the unbundled provision of public goods of different tiers by a different provider for each tier, each of them accountable to the voters via elections. This novel perspective allows us to identify two new effects of decentralization. The first effect provides an efficiency advantage to centralization because the central provider can reallocate resources among the different tiers of public goods after shocks to the prices of these public goods occur. The second effect shows that unbundling the provision of public goods increases electoral control. Finally, we compare both effects and find that centralization will dominate over decentralization when public goods prices are more volatile and the option of transferring resources among tiers of public goods acts as an insurance device. Decentralization dominates when the environment is more stable and voters can monitor the providers of public goods more tightly.

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1 Introduction

In the last decades many developed and developing countries have adopted decentralization reforms with the aims, among others, of improving the efficiency of public service delivery and the accountability of their governments. This, in turn, should have fostered economic growth and improved the living standards of the population of these countries. The mechanisms through which decentralization is supposed to deliver these benefits are numerous and a large amount of research has been devoted to the study of these mechanisms.

However, almost all the existing theoretical models on decentralization share a common approach. They understand centralization as the provision of one public good to a defined territory by a single authority, and decentralization as the transfer of this responsibility to a larger number of authorities, each of them providing the same public good to a subset of the previous territory. We call this approach *geographical decentralization*. This way of understanding decentralization has proven to be very fruitful and has identified several effects of how decentralization affects the provision of public goods.[1]

All these effects are focused on the geographical dimension of decentralization. We argue that there are additional effects arising from unbundling the provision of public goods. Decentralization may entail a deeper transformation than just the geographical splitting of the provision of one public good. In fact, the different levels of the administrations of the state provide a bundle of public goods, ranging from national defense and securing law and order, to public schools and public sport halls. From the perspective of the citizen of a democratic state, centralization is a regime in which most public goods are delivered by a single authority: the central government, accountable to the voters via elections, or by agents of this central authority, who are ultimately accountable to the central government. Under decentralization, the public goods are delivered by two or even more authorities, each of them separately accountable to the voter in elections, which often take place at different moments in time. For instance, a given citizen may receive public goods such as military defense and monetary policy from the central government, education and health from the sub-national government of his state or region, and waste collection from the local government of his municipality, all of them accountable to the citizen in different elections.[2]

We show in this paper that having one single provider of a set of public goods or having

[1] For a survey of these effects see for instance Bardhan (2002), Treisman (2007) or Ahmad and Brosio (2006).

[2] The concept of bundling of issues has a long tradition in theory of the firm, see for instance Bolton and Dewatripont (2005, Ch.6). In this literature this concept is mainly applied to problems of sellers of two goods facing some uncertainty about the preferences of the buyer and deciding whether to sell the two goods bundled or separated. In the field of political economy, Besley and Coate (2003b) and (2008) analyze the problem of bundling two political issues with different saliency for the voters into one single election and how it affects the risk of regulatory capture of the less salient issue. Our approach considers both public goods equally salient in order to clearly present the effects we have identified.

more than one provider, each of them responsible for providing a partition of the set of public goods, will entail significant differences in efficiency and in accountability which have not yet been identified in the literature.

The first effect implies changes in the efficiency in the provision of public goods. The *geographical decentralization* literature has already identified several ways in which decentralization affects the efficiency of the provision of public goods. For instance, and without attempting to be exhaustive, Tiebout (1956) showed that perfectly mobile citizens and decentralized provision of public goods lead to an efficient allocation of public goods; decentralization is also supposed to enable local governments to make a better use of their information advantage (Hayek, 1945) or to adapt the provision of local public goods to the preferences of the local population (Alesina and Spolaore, 1997 or Strumpf and Oberholzer-Gee, 2002); centralizing the provision of public goods to several jurisdictions could allow for the achievement of economies of scale (Oates, 1972); the existence of inter-jurisdictional externalities or spillovers in the provision of public goods (Oates, 1972) or in taxation, known as tax competition (Wilson, 1999), could make centralization more efficient since it can internalize these externalities or spillovers. All these effects assume only one public good and would never arise, by definition, in a one-jurisdictional political unit.

In our first effect we depart from this literature by showing an effect that arises when additional public goods are provided, and that works even if we assume only one jurisdiction. Our effect is based on the ability of a provider delivering more than one public good to transfer resources from one good to another. This ability becomes relevant under two assumptions: first, public goods are subject to asymmetric shocks in their costs or in the consumers' relative preferences for these goods. As a result, the optimal allocation of resources among public goods will depend on the realization of the shocks. Second, the resources of the providers are constrained, so that particularly strong shocks can bring the optimal bundle of public goods out of the feasibility constraint of the provider. Under these assumptions, the provider of one public good facing a negative shock might be forced to deliver a sub-optimal amount, while the provider of another public good in the same jurisdiction might enjoy a positive shock. Welfare could be improved if resources were transferred from the provider of one public good to the other. However, decentralized providers typically have neither the mechanisms nor the incentives to transfer resources among them. A provider responsible for both public goods might transfer resources among them and act, in fact, as an insurance for the consumer. [3]

[3]Two additional strands of the literature are also relevant for this effect. First, the multi-task principal agent literature addresses the problems of an agent who must perform two or more tasks as it is the case here, where the centralized provider must allocate his resources over two public goods. This literature has identified several issues arising in this type of situations. One of the main concerns is what occurs when one of the tasks is imperfectly monitored by the principal and the other does not (Holmstrom and Milgrom, 1991). In this case, effort will be inefficiently allocated to the task that can be better monitored. Many other effects studied in the multitask literature are also likely to arise in bundled provision of public goods and offer a promising line

In order to show this effect, we develop a model in which one single agent provides two public goods and maximizes the welfare of a single consumer. We compare it to the case when each provider is responsible for one of the two public goods, and both attempt to maximize the welfare of the single consumer. We show that the ability of the centralized provider to allocate resources from one public good to the other grants him an efficiency advantage over the two decentralized providers, who have no incentive to transfer resources among themselves.

The second identified effect changes the incentives of a self-interested provider of public goods and gives advantage to decentralization over centralization thanks to enhanced electoral accountability. In the *geographical decentralization* literature, models assuming self-interested politicians are also abundant. The pioneering work of Brennan and Buchanan (1980) showed that inter-jurisdictional competition among decentralized geographical units could be a way to "tame the Leviathan" if citizens are mobile. One strand of the literature focuses on the effects of the assignment of fiscal powers among tiers of the government on the incentives of public officers.[4] For a comprehensive review of these types of effects see Weingast (2009).

More relevant for our second effect is the literature on electoral accountability. This literature studies the ability of voters to use elections as a device to discipline poor performing politicians and to select politicians that voters expect to be more competent, honest, or closer to their preferences. Models of electoral accountability and decentralization show how this ability greatly differs if instead of having one elected politician responsible for policy-making in all jurisdictions, there is one elected politician responsible for policy-making in each jurisdiction. Therefore, they are based on the *geographical decentralization* approach as well. For a review of these effects see Lockwood (2006) or Persson and Tabellini (2000).[5]

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of future research. However, as far as we know, there are no studies on the advantage of multi-tasks in terms of insurance against shocks. The other related strand of the literature focuses on the insurance component of federations, (see for instance Persson and Tabellini (1996a) and (1996b) and Lockwood (1999)). But, again, this literature addresses the problem from a geographical perspective, where jurisdictions forming a federation ensure each other against imperfectly-correlated geographically-located shocks. No mention is made in this literature to the fact that a similar effect arises when the provision of public goods is bundled and shocks are public good-specific instead of location-specific.

[4]Examples of the consequences of the different arrangements of the assignment of fiscal powers range from over- or under- taxation, inefficient allocation of intergovernmental grants (Solé-Ollé and Sorribas-Navarro, 2008 among many others), neglect of the enforcement by local governments of central government regulation (Cai and Treisman, 2004) or underinvestment in public goods that could enhance future tax revenues (Zhuravskaya, 2000 and Jin et al., 2005) or rent extraction and corruption (Arikan, 2004).

[5]Besley and Coate (2003a) show the problem, inherent to any centralized system, of aggregating the preferences of the different jurisdictions if public goods cannot be adapted to each jurisdiction and preferences are heterogeneous. Seabright (1996) argues that, under centralization, a national incumbent only needs to please half of the jurisdictions plus one in order to be re-elected. A self-interested incumbent will thus neglect the other half of the jurisdictions that are not necessary for his re-election. This leads to a lower probability of a single jurisdiction being pivotal to the re-election of the incumbent implying lower accountability under centralization. Hindriks and Lockwood (2009) show the same "neglect of the minority" mechanism as Seabright (1996) but use a more advanced electoral accountability model, adapted from Besley and Smart (2007). This model allows the study of adverse selection effects (selection mechanism) and moral hazard effects (disciplining mechanism) operating at the same time. Kessing (2010) also uses a similar framework to show how random

The effect on electoral accountability we identify arises from the differences in the incentives of the providers if the provision of public goods is bundled into one single provider or if the provision of each public is unbundled to different authorities, even if they are all in the same unique jurisdiction. We show that, under centralization, voters can only punish or reward the incumbent for the overall performance in the provision of all public goods. Hence, the incumbent can shirk in the provision of some of them and still get re-elected. Under decentralization, each independent provider is under the spotlight and cannot shirk without being voted out of office. Therefore, the clear separation of responsibilities under decentralization empowers voters and makes democratic elections more efficient in disciplining politicians.

In order to show that the bundling or unbundling of public goods provision also matters for electoral accountability, even in a scenario without geographical decentralization, we develop an electoral control model building on Ferejohn (1986) and Barro (1973) and adapt them our approach to decentralization. Although models such as Hindriks and Lockwood (2009) already analyze electoral accountability under *geographical decentralization* in a sophisticated fashion, we use a more simplified model in order to better illustrate effects from unbundling the provision of public goods.

Finally, we combine both effects and determine which system is more advantageous, and under which circumstances. We deliberately disregard any other potential effect of decentralization in order to avoid confounding effects that could blur our results, although we acknowledge the existence and importance of these other effects.

We find that centralization dominates when the volatility of public goods is high. In this case, the insurance effect of the after-shock transfers a centralized provider can perform is more valuable. Decentralization dominates when the volatility of the public goods is relatively low. In this case, the voter can effectively monitor the different providers of public goods and exert more electoral control.

The structure of the paper is as follows: section 2 presents the model with benevolent public goods providers and shows how centralization can achieve higher efficiency through the transfer of resources among public goods. Section 3 assumes self-interested politicians and develops an electoral control model. It shows both effects. Section 4 gives values to the parameters of the model of section 2 and compares the two effects simultaneously. Section 5 concludes.

factors affecting re-election can influence decentralized and centralized systems differently.

2 Benevolent public good providers

We illustrate the first effect through a model in which providers of public goods are benevolent. We assume, for simplicity, that there are only two public goods, one is the set of all national public goods and the other the set of all local public goods. Both public goods are modelled to be symetric, therefore it is irrelevant which public good is provided by which tier. There is only one representative jurisdiction with one representative consumer of public goods. Both public goods have equal weight in the utility function of the consumer:[6]

$$U = y_1 + y_2$$

The production function for each public good is:

$$y_i \quad = \quad \varepsilon_i \cdot e_i$$

where y_i is the output or amount of public good $i = [1, 2]$, e_i is the level of effort invested by the provider in producing the public good i and ε_i is the realization of a random shock affecting the supply or the production of the public good.[7] The shocks are identically and independently distributed following the density function $f(\varepsilon)$, where $\varepsilon_i > 0$ in any case.

Under decentralization there is one different provider responsible for each public good. In this section we assume providers are benevolent; they maximize consumer utility, but must carry a cost for the effort of providing public goods. The utility function of the provider of public good i is:

$$V_i^P = y_i - e_i^{\phi}$$

$$\text{s.t.} \quad 0 \leq e_i \leq \bar{e}$$

where $\phi > 1$ is the disutility of the effort of providing public goods or the opportunity cost of alternative uses of this effort.[8] Additionally, there is a natural restriction in the maximum

[6]With this specification we abstract from the potential effects of different levels of salience of each public good studied in Besley and Coate (2003b) and (2008) and from the potential effects of spillovers among public goods often discussed in the literature, e.g. Oates (1972) or Besley and Coate (2003a).

[7]By modeling the production function in this way we avoid potential effects derived from economies of scale under centralization. Economies of scale are already broadly studied in the strand of the literature analyzing the size of the nations and the determinants of decentralization. See for instance or Alesina and Spolaore (1997) or Panizza (1999).

[8]The assumption that $\phi > 1$ avoids corner solutions. Values $0 < \phi < 1$ would imply that even with identical positive shocks to both public goods, the incumbent would prefer to exert effort in only one public good rather than splitting effort among both of them.

total effort the provider can invest, $\bar{e}$.

Under decentralization this problem has two solutions, depending on whether the constraint is binding or not:[9]

In the non-binding case: $e_i^{dc,n} = \left(\frac{\varepsilon_i}{\phi}\right)^{\frac{1}{\phi-1}}, \quad \text{if} \quad \left(\frac{\varepsilon_i}{\phi}\right)^{\frac{1}{\phi-1}} \leq \bar{e}$

In the binding case: $e_i^{dc,b} = \bar{e}, \quad \text{if} \quad \left(\frac{\varepsilon_i}{\phi}\right)^{\frac{1}{\phi-1}} > \bar{e}$

Both solutions give always positive utility to the provider[10] and therefore the providers always provide a positive amount of public goods.

Under centralization the utility function of the provider of both public goods is:

$$V^P = y_1 + y_2 - e_1^{\phi} - e_2^{\phi}$$

$$\text{s.t.} \quad 0 \leq e_1 + e_2 \leq 2 \cdot \bar{e}$$

The disutility of providing each public good is additive and separable. [11]

When the constraint is not binding the solution is the same as under decentralization:

$$e_i^{c,n} = \left(\frac{\varepsilon_i}{\phi}\right)^{\frac{1}{\phi-1}}, \quad \text{if} \quad \left(\frac{\varepsilon_1}{\phi}\right)^{\frac{1}{\phi-1}} + \left(\frac{\varepsilon_2}{\phi}\right)^{\frac{1}{\phi-1}} \leq 2 \cdot \bar{e}$$

The reason why both solutions are the same is that the optimal amount of public good in both cases is interior to the budget constraint and the optimum is feasible in both cases.

When the constraint is binding, an optimal constrained solution exists if there is a pair $(e_1^{c,b}, e_2^{c,b})$ that satisfies the optimality condition:

$$e_i^{c,b} = \left[\frac{(\varepsilon_1 - \varepsilon_2)}{\phi} + \left(2\bar{e} - \left(e_i^{c,b}\right)^{\phi-1}\right]^{\frac{1}{\phi-1}}$$

[9] Notice that if the provider would not suffer any disutility or cost from providing public goods, the optimal solution would be to invest all effort $\bar{e}$ in the more productive public good, namely the one with the highest realization of ε_i.

[10] In order to see why, consider first $e_i^{dc,n}$. Plugging this expression into $e_i \cdot \varepsilon_i - e_i^{\phi} > 0$ leads to $\phi > 1$, which is true by definition. In the case of $e_i = e_i^{dc,b}$, plugging it into $e_i \cdot \varepsilon_i - e_i^{\phi} > 0$ leads to $(\varepsilon_i)^{\frac{1}{\phi-1}} > \bar{e}$. This expression will always hold when we have a constrained solution, $(\varepsilon_i/\phi)^{\frac{1}{\phi-1}}$, because $(\varepsilon_i)^{\frac{1}{\phi-1}} > (\varepsilon_i/\phi)^{\frac{1}{\phi-1}} > \bar{e}$.

[11] This is reasonable if we assume that the central provider can hire agents to provide these public goods and is able to closely monitor them at no cost. We do this in order to avoid differences between centralization and decentralization motivated by the existence of economies or dis-economies of scale in the provision of public goods, which are already known to the literature (see Oates (1972) among many others).

This problem does not always have a solution that satisfies both the optimality condition and the budget constraint with strict equality. For instance, if $\phi = 2$ and $\bar{e} < \frac{\varepsilon_1 - \varepsilon_2}{4}$ the problem does have a solution. However, many pairs $(e_1 > 0, e_2 > 0)$ satisfy the budget constraint and give positive utility to the provider. The solutions under decentralization are among these feasible pairs.[12]

Proposition 1 *For given $\phi > 1$, $\varepsilon_1 > 0$ and $\varepsilon_2 > 0$ and for the values of (e_1, e_2) that maximize the utility of the provider under decentralization and under centralization:*

$$U\left(e_1^c, e_2^c\right) \geq U\left(e_1^{dc}, e_2^{dc}\right)$$

Proof see appendix

The utility of the consumer under centralization is larger than or equal to what it would be under decentralization. The reason for this superiority is the ability of the centralized provider to transfer effort among public goods.

3 Electoral control of self-interested providers of public goods

In this section we show the second effect we identified, together with the first effect already presented. We expand the model of section one and incorporate some elements of the classical Ferejohn (1986) model of electoral control. This model had only one unique public good and we develop it so that it can deal with multiple public goods, making the model suitable to the study of centralization and decentralization. For simplicity we consider the same two public goods as in the previous section. In contrast with the previous section, we assume now that providers of public goods are self-interested and do not provide public goods unless an incentive is offered to them. The incentive in this case is the possibility of being re-elected for another term if voters are pleased. Being re-elected represents enjoying the benefits of holding office another term plus having the option of being re-elected for another period.

3.1 Setup of the model of electoral control

The utility function of the consumer and the production functions are the same as in the previous section. Now the shocks to the production of public goods ε_i can only take two

[12] In order to see why, notice first that the solutions for decentralized provision also satisfy the budget constraint under centralization. Notice then that if the utility under decentralization is positive for both public goods, so will it be for both terms of the utility function of the centralized provider.

possible values: with probability p, the shock takes a high value, $\varepsilon_i = \bar{\varepsilon}$ while with probability $(1-p)$, the shock takes a low value, $\varepsilon_i = \underline{\varepsilon}$, where $\bar{\varepsilon} > \underline{\varepsilon} > 0$. The shocks for both public goods follow an identical distribution, but the realizations are independent. The voter can neither observe ε_i nor e_i, but can observe y_i for both $i = [1, 2]$. The provider of the public goods can observe both ε_i and e_i. Therefore, the larger the volatility of these shocks, the larger the asymmetry of information.

Public good providers are now self-interested. The single-period utility of the office holder in the centralized case is:

$$V = \chi^c - e_1^\phi - e_2^\phi$$

and in the decentralized case:

$$V_i = \chi^{dc} - e_i^\phi$$

where χ^c and χ^{dc} are the perquisites of holding office in each regime. For simplicity we will assume that $\chi^c = 2 \cdot \chi^{dc}$, which means that the perquisites under centralization are the same as the aggregated perquisites under decentralization.

Elections work in the following way: At the end of the term, the voter can either re-elect the incumbent or vote him out of office and replace him by a new provider of public goods. We assume that the candidates to replace the incumbent are drawn randomly from a pool of infinite candidates.[13] All potential candidates are identical. Therefore, incumbents have no signaling motives for investing effort. For the voter, the only observable indicator of the performance of the office holder is the level of output, and the only disciplining tool available to him is the non re-election threat. This threat is a retrospective voting rule linking re-election with a certain level of observed performance. The voting rule specifies the minimum amount of utility (henceforth referred to as cutoff value of voter's utility) that the voter must receive in order to re-elect the incumbent.[14]

The sequence of the game is as follows:
1) The voter chooses centralization or decentralization.

[13] In Ferejohn (1986) there is still a non-negligible probability of returning to office in the future if the incumbent is voted out of office. This decreases the differential value of staying in office an additional term and hence weakens the incentives of the incumbent to exert effort. Ferejohn (1986) aimed at showing that bi-partidism weakens the incentives of politicians since in a two party system the probability of returning to office once the replacement is voted out of office is almost certain. We are not interested in the impact of bi-partidism here, hence by assuming that the candidates to replace the incumbent are drawn randomly from a pool of infinite candidates we ensure that, once an incumbent is voted out of office, the probability that he returns to office is almost zero, which simplifies calculations.

[14] See Ferejohn (1986) or Banks and Sundaram (1998) for applications of cutoff values conditioning re-election.

2) If centralization was chosen, the voter sets an overall cutoff value of aggregated output. If decentralization was chosen, the voter sets a cutoff value for each specific public good provider.
3) The provider of public goods observes the realization of the shock that affects the public goods he is responsible for and chooses his level of effort.
4) The voter observes the level of output of public goods 1 and 2. Under centralization the voter re-elects the incumbent for another period if the overall level of public goods is greater than or equal to the overall cutoff value. If not, incumbent is voted out of office and a new candidate is randomly chosen to replace him. Under decentralization the voter compares the level of each public good with its specific cutoff value. The voter re-elects the provider of a public good for another period if the provided level is larger than or equal to the cutoff level. If the level of output of that public good does not reach the cutoff level, the incumbent responsible for that public good is voted out of office and a new candidate is randomly chosen to replace him.

3.2 The solution under decentralization

Under decentralization we have a different incumbent responsible for delivering each public good i. The voter sets a cutoff level of output $\hat{y}_{dc,i}$ of public good $i = [1, 2]$ for the provider of public good i as a condition to re-elect him. The problem of each incumbent is to choose his optimal level of effort for a given cutoff value and then decide whether it is better for him to exert this effort or not. The problem of the voter is to set the optimal re-election cutoff value for each public good such that his expected utility is maximized. The problem will be solved by backward induction.

The first step is to determine the optimal response of the office holder to each possible size of the shock and to each cutoff level of public good i. The single-period problem of each office holder is the following:

$$\max_{e_i} V_i \quad = \quad \chi^{dc} - e_i^{\phi}$$

The incumbent must satisfy the following constraint if he wants to be re-elected:

$$\text{s.t.} \quad \hat{y}_{dc,i} \leq \quad \varepsilon_i \cdot e_i$$

Therefore, the minimum effort the incumbent must exert in order to be re-elected is:

$$\hat{e}_{\,dc,i} \;=\; \frac{\hat{y}_{dc,i}}{\varepsilon_i}$$

The incumbent will exert this minimum level of effort only if the benefit of being re-elected (holding office in period $t+1$) minus the disutility of the effort required to be re-elected is larger than or equal to the utility that the office holder can obtain from being voted out of office but without exerting any effort. The value of being voted out of office is normalized to zero for the sake of simplicity. Furthermore, the probability of returning to office is practically zero since there is an infinite number of candidates. Formally, the condition will be:

$$\chi^{dc} - \left(\frac{\hat{y}_{dc,i}}{\varepsilon_i}\right)^{\phi} + \beta \cdot V^{IN}_{t+1} \geq \chi^{dc}$$

where β is the discount factor $0 < \beta < 1$ and V^{IN}_{t+1} is the utility of the office holder at period $t+1$ if he is in office. In order to determine $V^{IN}_{t+1,i}$ we define $q(\hat{y}_{dc,i})$ as the probability of the realization of the shock being such as to make it rational for the incumbent to exert effort again and be re-elected for period $t+2$. Accordingly, $(1 - q(\hat{y}_{dc,i}))$ will be the probability that the shock is so small that the incumbent prefers not to exert effort and lets himself be voted out of office:

$$V^{IN}_{t+1,i} = \chi^{dc} \,+\, q(\hat{y}_{dc,i}) \,\cdot\, \Big(-(\hat{e}_{\,dc,i})^{\phi} + \,\beta\,\cdot\, V^{IN}_{t+2,i}\Big)$$

which is equivalent to:

$$V^{IN}_{t+1,i} = \big(1 + q(\hat{y}_{dc,i}) \cdot \beta + q(\hat{y}_{dc,i})^2 \cdot \beta^2 + \cdots\big) \cdot \chi^{dc} \,-$$

$$-\, \big(1 + q(\hat{y}_{dc,i}) \cdot \beta + q(\hat{y}_{dc,i})^2 \cdot \beta^2 + \cdots\big) \cdot q(\hat{y}_{dc,i}) \cdot \hat{e}^{\phi}_{\,dc,i}$$

therefore:

$$V^{IN}_{t+1,i} = \frac{1}{1 - q(\hat{y}_{dc,i}) \cdot \beta} \cdot \Big(\chi^{dc} -\, q(\hat{y}_{dc,i}) \cdot \hat{e}^{\phi}_{\,dc,i}\Big)$$

The maximum cutoff value that the voter can set for a a given ε_i and still induce the incumbent to exert effort will then be:

$$\hat{y}_{dc,i} = \Big(\beta \cdot \chi^{dc}\Big)^{1/\phi} \cdot \varepsilon_i$$

If the voter could observe the realization of the shock before choosing the cutoff values, he would set a cutoff value for each possible realization. Defining $\hat{y}^{H}_{dc,i}$ and $\hat{y}^{L}_{dc,i}$ as the cutoff values when $\varepsilon_i = \bar{\varepsilon}$ and $\varepsilon_i = \underline{\varepsilon}$ respectively, these cutoff values would be set at the following values:

$$\hat{y}^H_{dc,i} = \left(\beta \cdot \chi^{dc}\right)^{1/\phi} \cdot \bar{\varepsilon} \quad , \quad \hat{y}^L_{dc,i} = \left(\beta \cdot \chi^{dc}\right)^{1/\phi} \cdot \underline{\varepsilon}$$

Since the shock is not observed, the voter needs to choose ex-ante the cutoff value that brings him the highest expected utility. Knowing the reaction function of the incumbent, the expected utility of the voter will depend on the cutoff value chosen. It is clear that any cutoff value other than $\hat{y}^H_{dc,i}$ or $\hat{y}^L_{dc,i}$ will be sub-optimal.[15] Therefore, the choice of the voter is between the high and the low cutoff values.[16] The expected welfare for each cutoff value is:

$$\mathrm{E}\left(U|\,\hat{y}^H_{dc,i}\right) = 2 \cdot p \cdot \hat{y}^H_{dc,i} \quad , \quad \mathrm{E}\left(U|\,\hat{y}^L_{dc,i}\right) = 2 \cdot \hat{y}^L_{dc,i}$$

The high cutoff value will be chosen if: $\mathrm{E}\left(U|\,\hat{y}^H_{dc,i}\right) \geq \mathrm{E}\left(U|\,\hat{y}^L_{dc,i}\right)$
which will only happen when:

$$p \geq \frac{\underline{\varepsilon}}{\bar{\varepsilon}}$$

which tells us that the larger the difference between the size of the high shock and the size of the low shock, the more likely it is that the voter chooses the high cutoff value. We define the cutoff probability as the probability where the voter is indifferent between the high and the low cutoff values: $\hat{p}^{dc} = \underline{\varepsilon}/\bar{\varepsilon}$.

Proposition 2 *Under decentralized provision of the public goods 1 and 2, the voter will set $\hat{y}_{dc,i} = \hat{y}^H_{dc,i}$ for $i = 1, 2$ if $p \geq \hat{p}^{dc}$ and $\hat{y}_{dc,i} = \hat{y}^L_{dc,i}$ for $i = 1, 2$ if $p < \hat{p}^{dc}$, where $\hat{p}^{dc} = \bar{\varepsilon}/\underline{\varepsilon}$ and*

$$\hat{y}^H_{dc,i} = \left(\beta \cdot \chi^{dc}\right)^{1/\phi} \cdot \bar{\varepsilon} \quad , \quad \hat{y}^L_{dc,i} = \left(\beta \cdot \chi^{dc}\right)^{1/\phi} \cdot \underline{\varepsilon}.$$

3.3 The solution under centralization

Bundling public good provision under centralization allows the incumbent to substitute effort among public goods in reaction to shocks and achieve higher efficiency. The voter is aware of this and will set a unique cutoff value taking this efficiency advantage into account. This unique cutoff value, $\hat{y}_c$, will allow the provider to freely allocate effort over the two public

[15] If $\varepsilon_i = \bar{\varepsilon}$ and $\hat{y}_{dc,i} > \hat{y}^H_{dc,i}$ the incumbent will provide nothing. If $\varepsilon_i = \bar{\varepsilon}$ and $\hat{y}_{dc,i} < \hat{y}^H_{dc,i}$ the voter could increase his utility by raising the cutoff value until $\hat{y}_{dc,i} = \hat{y}^H_{dc,i}$. The same applies for $\varepsilon_i = \underline{\varepsilon}$ and values of $\hat{y}_{dc,i} \neq \hat{y}^L_{dc,i}$

[16] It might still be possible to set the cutoff value of one public good high and the cutoff value of the other public good low. We can show that this solution is dominated by the two symmetric cutoff values and hence we will not contemplate it any longer.

goods and be re-elected as long as he provides the cutoff value aggregate level of public goods. This case will also be solved by backward induction. First we find the optimal effort that the incumbent will exert for a given cutoff value set by the voter, then we find the maximum cutoff value that the voter can set in case the realization of shocks is known. This will leave the incumbent indifferent between exerting and not exerting effort. Finally, we determine which cutoff value the voter will choose depending on the distribution of the shocks.

The single period problem of the office holder if he wants to achieve the cutoff value and be re-elected is the following:

$$\max_{e_1,e_2} V \ = \ \chi^c - \ e_1^{\phi} \ - \ e_2^{\phi}$$

$$\text{s.t. } \varepsilon_1 \cdot e_1 + \varepsilon_2 \cdot e_2 \geq \hat{y}_c$$

Setting the Lagrangian and differentiating with respect to e_1 and e_2 we find:

$$\hat{e}_{c,i} = \left(\frac{\varepsilon_i^{\frac{1}{\phi-1}}}{\varepsilon_1^{\frac{\phi}{\phi-1}} + \varepsilon_2^{\frac{\phi}{\phi-1}}} \right) \cdot \hat{y}_c$$

where $\hat{e}_{c,i}$ is the minimum effort that the incumbent exerts in producing public good i in order to achieve the cutoff value $\hat{y}_c$.

The incumbent will only exert effort $\hat{e}_{c,i}$ if the expected future utility derived from being re-elected is at least as large as the disutility of exerting the effort required to be re-elected. Recall that we assumed that the future utility after being voted out of office is normalized to zero:

$$\chi^c - {e_1}^{\phi} - {e_2}^{\phi} + \beta \cdot V_{t+1}^{IN} \geq \chi^c$$

Plugging the expressions for minimum effort of the incumbent into this expression and using the same logic for calculating $\mathrm{V}_{\mathrm{t+1}}^{\mathrm{IN}}$ as in the decentralized case, we find that the maximum cutoff value that the voter can set will be:

$$\hat{y}_c = (\beta \cdot \chi^c)^{\frac{1}{\phi}} \cdot \left(\varepsilon_1^{\frac{\phi}{\phi-1}} + \varepsilon_2^{\frac{\phi}{\phi-1}} \right)^{\frac{\phi-1}{\phi}}$$

If the voter were able to observe the realization of the shocks before setting the cutoff values, there would be four different values, one for each possible state of nature. These four possible states of nature lead us to define the following scenarios: The first scenario will be referred to as the *"high productivity"* scenario. Here both shocks are high: $\varepsilon_1 = \varepsilon_2 = \bar{\varepsilon}$ and the probability of this scenario is p^2. The second scenario will be referred as the *"medium productivity"* scenario, where one shock is high and the other one is low: $\varepsilon_1 = \bar{\varepsilon}$ and $\varepsilon_2 = \underline{\varepsilon}$ or $\varepsilon_1 = \underline{\varepsilon}$ and $\varepsilon_2 = \bar{\varepsilon}$. The probability of this scenario is $2 \cdot (1-p) \cdot p$. The third scenario will be referred as the *"low productivity"* scenario. Here both shocks are low $\varepsilon_1 = \varepsilon_2 = \underline{\varepsilon}$ and the probability is: $(1-p) \cdot (1-p)$.

The cutoff values of each public good for each scenario are:

- High productivity: $\hat{y}_c^H = (\beta \cdot \chi^c)^{\frac{1}{\phi}} \cdot 2^{\frac{\phi-1}{\phi}} \cdot \bar{\varepsilon}$
- Medium productivity: $\hat{y}_c^M = (\beta \cdot \chi^c)^{\frac{1}{\phi}} \cdot \left(\bar{\varepsilon}^{\frac{\phi}{\phi-1}} + \underline{\varepsilon}^{\frac{\phi}{\phi-1}}\right)^{\frac{\phi-1}{\phi}}$
- Low productivity: $\hat{y}_c^L = (\beta \cdot \chi^c)^{\frac{1}{\phi}} \cdot 2^{\frac{\phi-1}{\phi}} \cdot \underline{\varepsilon}$

It is straightforward that $\hat{y}_c^H > \hat{y}_c^M > \hat{y}_c^L$.

Under imperfect information, the voter must choose ex-ante a unique cutoff value that will maximize his expected utility. As in the decentralization case, it is clear that any cutoff value that does not coincide with $\hat{y}_c^H, \hat{y}_c^M$ or $\hat{y}_c^L$ will not be optimal. The choice among the different cutoff values will depend on a trade-off between expected losses due to *excessive leniency* versus expected losses due to *excessive rigor*. Losses due to *excessive leniency* happen when in a given scenario and for a given realization of the shocks, the cutoff value set ex-ante by the voter turns out to be lower than the cutoff value that would have been chosen under perfect information. As a result, the effort exerted by the incumbent will be lower in this scenario than it would have been under perfect information. Losses due to *excessive rigor* happen when in a given scenario and for a given realization of the shocks the cutoff value set ex-ante by the voter turns out to be higher than the cutoff value that would have been set under perfect information. As a result, the incumbent exerts no effort in these scenarios.

The expected utility of each cutoff value will be the following: when $\hat{y}_c = \hat{y}_c^H$, the incumbent will exert optimal effort in the *high productivity* scenario, and there will be no losses due to *excessive leniency*. In the *medium* and *low productivity* scenarios, the cutoff value will be too high and no effort will be exerted. Therefore, there will be foregone utility due to *excessive rigor*. The expected utility derived from this cutoff value will be:

$$\mathrm{E}\left(U | \, \hat{y}_c^H\right) = p^2 \cdot \hat{y}_c^H = p^2 \cdot (\beta \cdot \chi^c)^{\frac{1}{\phi}} \cdot 2^{\frac{\phi-1}{\phi}} \cdot \bar{\varepsilon}$$

When $\hat{y}_c = \hat{y}_c^M$, the incumbent will exert optimal effort in the *medium productivity* scenario. In the *high productivity* scenario, the medium cutoff value will turn out to be *too lenient*, and the incumbent will only exert effort in order to achieve $\hat{y}_c^M$ which is lower than $\hat{y}_c^H$. In the *low productivity* scenario, the medium cutoff value will turn out to be *too rigorous*, and no effort will be exerted. The expected utility derived from this cutoff value will be:

$$\mathrm{E}\left(U|\,\hat{y}_c^M\right) = \left(p^2 + 2\cdot(1-p)\cdot p\right)\hat{y}_c^M = (2-p)\cdot p\cdot(\beta\cdot\chi^c)^{\frac{1}{\phi}}\cdot\left(\bar{\varepsilon}^{\frac{\phi}{\phi-1}} + \underline{\varepsilon}^{\frac{\phi}{\phi-1}}\right)^{\frac{\phi-1}{\phi}}$$

In the *medium productivity* scenario, the medium cutoff value allows the incumbent to substitute effort from the public good suffering the low productivity shock to the good enjoying the high productivity shock no matter which public good receives which shock. This possibility of substitution is not available for the decentralized provider of public goods and under some conditions this possibility renders centralization superior to decentralization, as we will show.

When $\hat{y}_c = \hat{y}_c^L$, the incumbent will exert effort in all scenarios, but this effort will be just sufficient to achieve this low cutoff value. Therefore, there will be no losses from *excessive rigor*, but there will be losses from *excessive leniency* in the *high* and *medium productivity* scenarios. The expected utility derived from this cutoff value will be:

$$\mathrm{E}\left(U|\,\hat{y}_c^L\right) = \hat{y}_c^L = (\beta\cdot\chi^c)^{\frac{1}{\phi}}\cdot 2^{\frac{\phi-1}{\phi}}\cdot\underline{\varepsilon}$$

The voter will choose the cutoff value that yields the higher expected utility. We compare pairwise the expected utility for different cutoff values.

Proposition 3 *Under centralized provision of the public goods 1 and 2, the voter will set the following cutoff value of the aggregated volume of public goods 1 and 2:*

$$\hat{y}_c = \begin{cases} \hat{y}_c^L & \textit{if} \quad p < \hat{p}_c^{LM} \\ \hat{y}_c^M & \textit{if} \quad \hat{p}_c^{LM} \leq p < \hat{p}_c^{MH} \\ \hat{y}_c^H & \textit{if} \quad p \geq \hat{p}_c^{MH} \end{cases}$$

Calculations are provided in the appendix.

4 Comparison of decentralization versus centralization

So far we have seen how the choice of the cutoff levels in each regime critically depends on p, ϕ, β, $\underline{\varepsilon}$ and $\bar{\varepsilon}$. Now we will see which regime will be chosen by the voter, assuming he knows these parameters and that he can choose the regime at a constitutional stage. For the sake of comparability we will assume in this section that $\phi = 2$ and that $\bar{\varepsilon} = 2 \cdot \underline{\varepsilon}$.
For these parameter values, the different probability threshold values will be: $\hat{p}^{dc} = 0.5$, $\hat{p}_c^{MH} = 0.88$, $\hat{p}_c^{LM} = 0.39$ and $\hat{p}_c^{LH} = 0.7$. For each value of p, the voter will choose the arrangement of provision of public goods that will deliver him the highest expected utility.

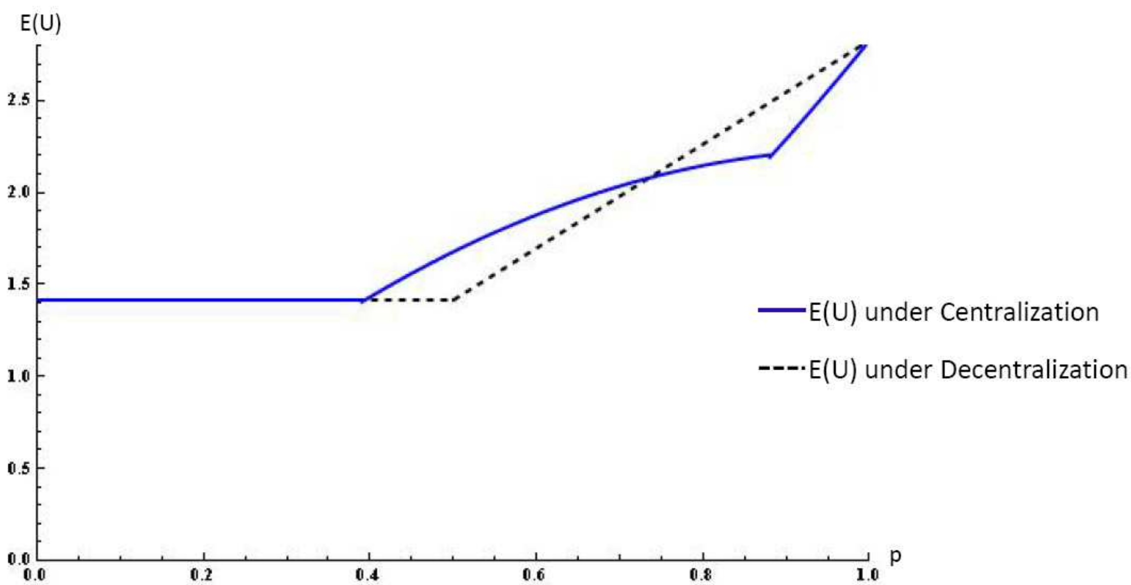

Figure 1: Expected utility under centralization and under decentralization

Figure 1 compares the levels of expected utility under each regime when $\phi = 2$ and $\bar{\varepsilon} = 2 \cdot \underline{\varepsilon}$ and $\underline{\varepsilon} = 1$.

Table 1 summarizes our results for the case when $\phi = 2$ and $\bar{\varepsilon} = 2 \cdot \underline{\varepsilon}$ and $\underline{\varepsilon} = 1$ (Calculations in the appendix). They neatly present the tradeoff between the two effects we have been discussing. For $0.39 > p > 0.74$ the volatility of public goods is high. Therefore the insurance effect of the medium cutoff value of centralization dominates decentralization. However, for $p \geq 0,74$ public goods are more predictable and the voter can better control the providers. Therefore, the insurance effect of centralization is no longer so profitable in comparison with the enhanced electoral control obtained under decentralization.[17]

[17]Simulations for other values of the parameters are available upon request. The results obtained for other parameter values only affect the relative position of the probability thresholds and the values of expected

Probability	Regime chosen	Cutoff value chosen
$p < 0.39$	Indifferent	$\hat{y}_c^L$ or $\hat{y}_{dc,i}^L$
$0.39 \leq p < 0.74$	Centralization	$\hat{y}_c^M$
$p \geq 0.74$	Decentralization	$\hat{y}_{dc,i}^H$

Table 1: Regime and cutoff value chosen

5 Conclusion

We have compared the level of public goods provision under two different regimes. In the first regime, the provision of two public goods is bundled under the responsibility of one single authority subject to electoral control. We called this regime centralization. In the second regime, the provision of the two public goods is unbundled and each public good comes under the responsibility of a different authority. Each authority is subject to elections. We called this regime decentralization.

Analyzing the levels of public goods provided in both regimes, we have shown the existence of two effects not yet identified in the literature. The first effect stems from the possibility of a centralized provider substituting effort among the different public goods he is responsible for. This possibility is not available to a provider of only one public good. For example, when an adverse shock affects only one tier, the centralized provider will be able to re-allocate resources from one tier to the other in order to neutralize the negative shock. In contrast, if the shock is too severe, since the decentralized provider does not have access to additional resources, he might not be able to react. The second effect comes from a better electoral control of public good providers under decentralization. The clear separation of responsibilities under decentralization makes shirking more difficult for the incumbent. The preferability of one regime or the other will depend, among other factors, on the volatility of the prices of public goods. If prices are highly volatile, the insurance effect of the transfers under centralization ensures a higher level of utility to the voters. If the prices of public goods are stable, providers of public goods can be better monitored and decentralization delivers a higher expected welfare. We

utility, but in all cases a clear pattern emerges: there is a first interval of low probability values in which the low cutoff value is preferred and therefore there is no difference between centralization and decentralization. Afterward, there is always a second interval in which centralization with medium cutoff values is preferred. Finally, for higher values of probability, decentralization with high cutoff value is always preferred.

have shown that these effects exist even in the absence of the traditional sources of differences discussed in the decentralization and fiscal federalism literature: spillovers, economies of scale in the production of public goods, heterogeneity of preferences, factor mobility, etc.

These results imply that the analysis of decentralization reforms should include an additional caveat disregarded so far in the literature. Volatility in the production and demand of public goods is a relevant factor to be taken into account in the analysis of the desirability of decentralization, especially if the goal is to strengthen the accountability mechanisms of developing countries. Although our model has confirmed the conventional wisdom that tells us that decentralization allows for a clear delimitation of responsibilities, accountability may not be higher under decentralization in all cases. In a highly volatile environment, with a strong asymmetry of information between voter and incumbent, a centralized government might be more able to respond to supply and demand shocks and ensure a certain level of provision of different goods to the voter. Decentralized providers of public goods might not be able to react to negative shocks and, as a consequence, might turn more often to private (often illegal) activities given that the legal path of pursuing re-election through better service to the voter might be less attractive. In developed countries, if we assume that the production and delivery of public goods are relatively stable, then decentralized provision of public goods might allow the voter to better allocate responsibilities and is more effective in disciplining incumbents.

We have restricted our analysis to the case of shocks to the production function of public goods, but the introduction of other types of shocks to the model, especially demand shocks, would yield similar results as long as the structure of the information asymmetry does not change - that is, as long as the shocks are only observable by the incumbent. Therefore the relevance of these findings should not be constrained to only supply shocks, but could also be extended to any kind of risk specific to public goods in general.

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Appendices

A Proof of Proposition 1

There are two possible cases to be considered depending on whether the values of ε_1 and ε_2 are equal or not. If $\varepsilon_1 = \varepsilon_2$, the problem becomes symmetric, and the solution for both centralization and decentralization - binding and non binding cases - $e_i = \bar{e}$. Hence $U\left(e_1^c, e_2^c\right) = U\left(e_1^{dc}, e_2^{dc}\right)$.

If $\varepsilon_1 \neq \varepsilon_2$, four further sub-cases can arise depending on whether the constraints are binding: in the first case, the solutions for centralization and decentralization are non-binding. We have already shown that in this case both solutions are identical, hence proposition 1 will hold with strict equality. In the second case, the constraint for centralization is non-binding while the constraint for decentralization are binding for one of the public goods and non binding for the other.[18] This occurs if:

$$\bar{e} - \left(\frac{\varepsilon_1}{\phi}\right)^{\frac{1}{\phi-1}} > \left(\frac{\varepsilon_2}{\phi}\right)^{\frac{1}{\phi-1}} - \bar{e} > 0$$

Henceforth, we will only consider the case when $\varepsilon_1 > \varepsilon_2$ since the case when $\varepsilon_2 > \varepsilon_1$ is symmetric. The first expression represents the excess of resources in the non-constrained public good (number 1 in this example). It is larger than the amount of resources required to achieve the optimum of public good 2 (second expression). A centralized provider can internally transfer the resources from public good 1 to public good 2 and achieve the optimum of both public goods.

In the third case, the constraint for centralization is binding, while the solutions for decentralization are binding for one of the public goods and non-binding for the other. For the case when $\varepsilon_1 < \varepsilon_2$ this happens when:

$$0 < \bar{e} - \left(\frac{\varepsilon_1}{\phi}\right)^{\frac{1}{\phi-1}} < \left(\frac{\varepsilon_2}{\phi}\right)^{\frac{1}{\phi-1}} - \bar{e}$$

The surplus of effort in the provision of public good 1 is lower than the effort required to achieve the optimum in public good 2. Hence, the constraint under centralization is binding. In this case, under decentralization, the constrained public good will be under-provided and the unconstrained public good will be optimally provided, but not all the capacity will be

[18] The case when the solution under centralization is binding and the solution under decentralization is non binding or vice-versa is mathematically not possible.

employed: [19]

$$e_1^{dc,n} = \left(\frac{\varepsilon_1}{\phi}\right)^{\frac{1}{\phi-1}} \quad < \quad \bar{e} \quad , \quad e_2^{dc,b} = \bar{e} \quad < \quad \left(\frac{\varepsilon_2}{\phi}\right)^{\frac{1}{\phi-1}} \quad > \bar{e}$$

Under centralization there will be no unemployed capacity:

$$e_1^{c,b} = \left(\frac{\varepsilon_1}{\phi}\right)^{\frac{1}{\phi-1}} < \bar{e} \quad , \quad e_2^{c,b} = 2 \cdot \bar{e} - \left(\frac{\varepsilon_1}{\phi}\right)^{\frac{1}{\phi-1}}$$

In this case, under decentralization, the total level of public goods provided will always be lower. Comparing the utility of the voter under decentralization with the utility of the voter under centralization:

$$\varepsilon_1 \cdot \left(\frac{\varepsilon_1}{\phi}\right)^{\frac{1}{\phi-1}} + \varepsilon_2 \cdot \bar{e} \quad < \quad \varepsilon_1 \cdot \left(\frac{\varepsilon_1}{\phi}\right)^{\frac{1}{\phi-1}} + \varepsilon_2 \cdot \left(2 \cdot \bar{e} - \left(\frac{\varepsilon_1}{\phi}\right)^{\frac{1}{\phi-1}}\right)$$

we can see that this inequality holds if $\left(\frac{\varepsilon_1}{\phi}\right)^{\frac{1}{\phi-1}} < \bar{e}$, which is the case since the constraint for public good 1 is non binding.

In the fourth possible case of $\varepsilon_1 \neq \varepsilon_2$, the constraints in both regimes are binding. Under decentralization, $e_1^{dc,b} = e_2^{dc,b} = \bar{e}$. Under centralization, the levels of effort do not have a closed form solution. However, we are only interested in showing that the utility of the voter under centralization is larger than under decentralization:

$$\varepsilon_1 \cdot e_1^{c,b} + \varepsilon_2 \cdot e_2^{c,b} > (\varepsilon_1 + \varepsilon_2) \cdot \bar{e}$$

To show this, we need to find a pair (e_1, e_2) that satisfies the budget constraint under centralization, $e_1 + e_2 = 2 \cdot \bar{e}$, and that yields more utility to the provider and to the voter than $(\bar{e}, \bar{e})$. Starting with the case $\varepsilon_1 > \varepsilon_2$, we define $e_1^c = \bar{e} + \mu$, where $0 < \mu \leq \bar{e}$, and $e_2^c = \bar{e} - \mu$. The budget constraint will be satisfied with strict equality. In this case, the provider will invest more effort than $\bar{e}$ if:

$$\varepsilon_1 \cdot (\bar{e} + \mu) - (\bar{e} + \mu)^{\phi} + \varepsilon_2 \cdot (\bar{e} - \mu) - (\bar{e} - \mu)^{\phi} \quad > \quad (\varepsilon_1 + \varepsilon_2) \cdot \bar{e} - 2 \cdot (\bar{e})^{\phi}$$

which leads to:

$$(\varepsilon_1 - \varepsilon_2) \cdot \mu \quad > \quad (\bar{e} + \mu)^{\phi} + (\bar{e} - \mu)^{\phi} - 2 \cdot (\bar{e})^{\phi}$$

Given that $\phi > 1$, then $(\bar{e} + \mu)^{\phi} + (\bar{e} - \mu)^{\phi} < 2 \cdot (\bar{e})^{\phi}$. Since the left hand side is positive

[19] If $\varepsilon_1 > \varepsilon_2$ the solution is symmetric.

$(\varepsilon_1 > \varepsilon_2)$ and the right hand side is always negative, this inequality will always hold. The last step is to show that the utility of the voter is larger with $(\bar{e}+\mu, \bar{e}-\mu)$ than with $(\bar{e}, \bar{e})$ Plugging the values of (e_1, e_2) into the voter's utility function and solving, we obtain $(\varepsilon_1 - \varepsilon_2)\cdot \mu > 0$, which will also hold since $\varepsilon_1 > \varepsilon_2$ and $\mu > 0$. ■

B Calculating the thresholds of probability for each cutoff value under centralization

The voter chooses the cutoff value under centralization that yields the highest expected utility, which will, in turn, depend on the value of p. The higher cutoff value, $\hat{y}_c^H$, is preferred to the medium cutoff value $\hat{y}_c^M$ if $\mathrm{E}\left(U|\,\hat{y}_c^H\right) \geq \mathrm{E}\left(U|\,\hat{y}_c^M\right)$, which means that:

$$p^2 \cdot \left(\hat{y}_c^H - \hat{y}_c^M\right) \;\geq\; 2 \cdot (1-p) \cdot p \cdot \hat{y}_c^M$$

The left hand side of the inequality is the differential expected gain in the high productivity scenario. Here, the high cutoff value is optimal and the medium cutoff value is *too lenient*. The right hand side of the inequality is the differential expected loss in the medium productivity scenario. Here, the high cutoff value is too rigorous and no effort is exerted, whereas the medium cutoff value is optimal.

This inequality will hold if and only if:

$$p \geq \frac{2 \cdot \hat{y}_c^M}{\hat{y}_c^H + \hat{y}_c^M}$$

which is equivalent to:

$$p \geq \frac{2 \cdot \left(\bar{\varepsilon}^{\frac{\phi}{\phi-1}} + \underline{\varepsilon}^{\frac{\phi}{\phi-1}}\right)^{\frac{\phi-1}{\phi}}}{2^{\frac{\phi-1}{\phi}} \cdot \bar{\varepsilon} + \left(\bar{\varepsilon}^{\frac{\phi}{\phi-1}} + \underline{\varepsilon}^{\frac{\phi}{\phi-1}}\right)^{\frac{\phi-1}{\phi}}} = \hat{p}_c^{MH}$$

where $\hat{p}_c^{MH}$ is the threshold value of p. For values of p below this threshold, the medium cutoff value is preferred, and for values of p above this threshold, the high cutoff value is preferred. It is straightforward to show that $0 < \hat{p}_c^{MH} < 1$, which means that there will always exist a threshold.

The expected utility from setting a medium cutoff value $\mathrm{E}\left(U|\,\hat{y}_c^M\right)$ will be larger than that of setting a low cutoff value $\mathrm{E}\left(U|\,\hat{y}_c^L\right)$ if $\mathrm{E}\left(U|\,\hat{y}_c^M\right) \geq \mathrm{E}\left(U|\,\hat{y}_c^L\right)$, which implies that:

$$\left(p^2 + 2(1-p)p\right) \cdot \left(\hat{y}_c^M - \hat{y}_c^L\right) \geq (1-p)^2 \cdot \hat{y}_c^L$$

The left hand side of the inequality is the differential expected gain in the medium and high productivity scenarios. In these scenarios, the low cutoff value will be *too lenient* in comparison to the medium cutoff value. The right hand side is the differential expected loss in the low productivity scenario. Here, the medium cutoff value is *too rigorous* and does not induce effort.

For values of p close to 1, the low productivity scenario becomes very unlikely and the medium cutoff level will be preferred to the low one. If p tends to zero, the low productivity scenario becomes very likely and the losses from the effort lost by setting the medium cutoff value will make the low cutoff preferable. In particular, the medium cutoff value will be preferred if:

$$p \geq 1 - \sqrt{\frac{\hat{y}_c^M - \hat{y}_c^L}{\hat{y}_c^M}}$$

which is equivalent to:

$$p \geq 1 - \sqrt{1 - \left(\frac{2 \cdot \underline{\varepsilon}^{\frac{\phi}{\phi-1}}}{\bar{\varepsilon}^{\frac{\phi}{\phi-1}} + \underline{\varepsilon}^{\frac{\phi}{\phi-1}}}\right)^{\frac{\phi-1}{\phi}}} = \hat{p}_c^{LM}$$

where $\hat{p}_c^{LM}$ is the threshold value of p. For values of p below this threshold, the low cutoff value will be preferred, and for values above the threshold, the medium cutoff value will be preferred. It can also be shown that $0 < \hat{p}_c^{LM} < 1$ which implies that this threshold probability always exists. Furthermore, it will always be that $\hat{p}_c^{MH} > \hat{p}_c^{LM}$.

The high cutoff value will be preferred to the low cutoff value if $\mathrm{E}\left(U|\,\hat{y}_c^H\right) \geq \mathrm{E}\left(U|\,\hat{y}_c^L\right)$ or, equivalently, if:

$$p^2 \cdot \hat{y}_c^H \geq \hat{y}_c^L$$

which just says that the expected gains from exerting higher control over the office holder (but only in the high performance scenario) must be larger than the utility that the lower cutoff value yields in all scenarios. We can transform this inequality into:

$$p^2 \cdot (\beta \cdot \chi^c)^{\frac{1}{\phi}} \cdot 2^{\frac{\phi-1}{\phi}} \cdot \bar{\varepsilon} \geq (\beta \cdot \chi^c)^{\frac{1}{\phi}} \cdot 2^{\frac{\phi-1}{\phi}} \cdot \underline{\varepsilon}$$

which will hold if and only if:

$$p \geq \sqrt{\frac{\underline{\varepsilon}}{\bar{\varepsilon}}} = \hat{p}_c^{LH}$$

where $\hat{p}_c^{LH}$ is the threshold value of the probability. For values of p below the threshold, the low cutoff value will be preferred. For values above the threshold, the high cutoff value will be preferred. Since $0 < \underline{\varepsilon} < \bar{\varepsilon}$, it can directly be seen that $0 < \hat{p}_c^{LH} < 1$.

Furthermore, it can also be shown that $\hat{p}_c^{LM} < \hat{p}_c^{LH} < \hat{p}_c^{MH}$ at least for any $\bar{\varepsilon} > \underline{\varepsilon} \geq 1$, $0 < \beta < 1$, $\phi > 1$ and $\chi^c > 0$.

C Calculating the values of the thresholds of probability for each regime and cutoff value

For the values of the parameters $\phi = 2$ and $\bar{\varepsilon} = 2 \cdot \underline{\varepsilon}$, we will have the following cutoff values:

in the decentralized case:

$$\hat{y}_{dc,i} = \begin{cases} \hat{y}_{dc,i}^{L} & \text{if} \quad p < 0.5 \\ \\ \hat{y}_{dc,i}^{H} & \text{if} \quad p \geq 0.5 \end{cases}$$

in the centralized case:

$$\hat{y}_c = \begin{cases} \hat{y}_c^{L} & \text{if} \quad p < 0.39 \\ \\ \hat{y}_c^{M} & \text{if} \quad 0.39 \leq p < 0.88 \\ \\ \hat{y}_c^{H} & \text{if} \quad p \geq 0.88 \end{cases}$$

Assuming that the voter is able to choose the structure of the state that brings him a larger expected utility, we have to analyze the following four cases:

$$\hat{y} = \begin{cases} \hat{y}^L_{dc,i} \quad \text{or} \quad \hat{y}^L_c \quad \text{if} \quad p < 0.39 \\ \\ \hat{y}^L_{dc,i} \quad \text{or} \quad \hat{y}^M_c \quad \text{if} \quad 0.39 \leq p \leq 0.5 \\ \\ \hat{y}^H_{dc,i} \quad \text{or} \quad \hat{y}^M_c \quad \text{if} \quad 0.5 \leq p < 0.88 \\ \\ \hat{y}^H_{dc,i} \quad \text{or} \quad \hat{y}^H_c \quad \text{if} \quad p \geq 0.88 \end{cases}$$

When $p < 0.39$, we have the lower cutoff value in both regimes. This means that the low level of effort will always be exerted, no matter the scenario. Furthermore, it can be shown that, if $\chi^c = 2 \cdot \chi^{dc}$, then $\mathrm{E}\left(U|\,\hat{y}^L_c\right) = \mathrm{E}\left(U|\,\hat{y}^L_{dc,i}\right)$. The voter is indifferent between centralization and decentralization. When $0.39 \leq p < 0.5$ the voter can choose between $\hat{y}^L_{dc,i}$ and $\hat{y}^M_c$. We have just seen that $\mathrm{E}\left(U|\,\hat{y}^L_c\right) = \mathrm{E}\left(U|\,\hat{y}^L_{dc,i}\right)$ and from the previous section we know that for $0.39 \leq p < 0.61$ we have $\mathrm{E}\left(U|\,\hat{y}^M_c\right) > \mathrm{E}\left(U|\,\hat{y}^L_c\right)$. Therefore, it must necessarily be that $\mathrm{E}\left(U|\,\hat{y}^M_c\right) > \mathrm{E}\left(U|\,\hat{y}^L_{dc,i}\right)$. This means that in this interval, centralization dominates. When $0.5 \leq p < 0.88$ then the voter can choose between $\hat{y}^M_c$ and $\hat{y}^H_{dc,i}$, decentralization is preferred if: $\mathrm{E}\left(U|\,\hat{y}^H_{dc,i}\right) \geq \mathrm{E}\left(U|\,\hat{y}^M_c\right)$. This inequality holds if:

$$p^2 \cdot \left(2 \cdot \hat{y}^H_{dc,i} - \hat{y}^M_c\right) \geq \left(2 \cdot p \cdot (1-p)\right) \cdot \left(\hat{y}^M_c - \hat{y}^H_{dc,i}\right)$$

The left hand side is the differential expected gain in the high productivity scenario. Under decentralization, both public goods are produced at its high cutoff value amount, whereas under centralization, the average production is only $\hat{y}^M_c < 2\hat{y}^H_{dc,i}$. The right hand side shows the differential expected loss in the medium productivity scenario. Under centralization, both goods are produced - more quantity of the good with high shock and less quantity of the good with low shock. In the decentralized case, only the good with high shock is produced. Recall that $\hat{y}_{dc,i}$ refers only to one public good, while $\hat{y}_c$ refers to both public goods.

In general, it can be shown that the inequality holds:

$$p \geq 2 - \left(\frac{2 \cdot \bar{\varepsilon}^{\frac{\phi}{\phi-1}}}{\bar{\varepsilon}^{\frac{\phi}{\phi-1}} + \underline{\varepsilon}^{\frac{\phi}{\phi-1}}}\right)^{\frac{\phi-1}{\phi}} = \hat{p}^{M,H}_{c,dc}$$

In our particular case with $\phi = 2$ and $\bar{\varepsilon} = 2 \cdot \underline{\varepsilon}$, the threshold probability level between centralization with medium cutoff value $\hat{y}^M_c$ and decentralization with high cutoff value $\hat{y}^H_{dc,i}$ is $\hat{p}^{M,H}_{c,dc} = 0.74$. Therefore, for $0.5 < p \leq 0.74$, centralization with medium cutoff value $\hat{y}^M_c$

dominates, and for $p \geq 0.74$, decentralization with high cutoff value $\hat{y}^H_{dc,i}$ dominates.

When $p \geq 0.88$, we compare the high cutoff values of decentralization and centralization: the decentralization regime is preferred if the inequality $\mathrm{E}\left(U|\,\hat{y}^H_{dc,i}\right) \geq \mathrm{E}\left(U|\,\hat{y}^H_c\right)$ holds, which means that:

$$p^2 \cdot \left(2 \cdot \hat{y}^H_{dc,i} - \hat{y}^H_c\right) + (2 \cdot (1-p) \cdot p) \cdot \hat{y}^H_{dc,i} \geq 0$$

Again, the first term of the left hand side of the inequality is the differential gain in the high productivity scenario. It can be shown that $2 \cdot \hat{y}^H_{dc,i} = \hat{y}^H_c$, implying that both regimes perform equally well in this scenario. In the medium productivity scenario however, the decentralized case produces the good with the high shock, whereas the centralized office holder has no incentives to exert effort at all. Clearly, decentralization with high cutoff value dominates centralization with high cutoff value.

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