

# Political decentralization and policy experimentation

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Since Justice Brandeis' 1932 remark that in a federal system states can serve as "laboratories" of democracy, a widespread belief has held that political decentralization stimulates policy experimentation. We reexamine the political economy underlying this claim, using a model of retrospective voting and contrasting centralized and decentralized institutions. Although under some conditions (when experiments are politically promising) decentralization can result in greater experimentation, several effects combine to lead, under most conditions, to both more frequent and better organized policy experimentation under centralized government.

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# 1 Introduction

Political decentralization is often thought to stimulate policy experimentation and innovation. Justice Brandeis made this argument famous in 1932 with his remark that in a federal system states can serve as “laboratories” to test novel policies.<sup>1</sup> Ever since, the notion has been influential in American jurisprudence, with more than three dozen judges citing Brandeis’ comment in their opinions (Greve 2001). It has been used in the Supreme Court to defend letting states set policy on everything from physician-assisted suicide and medical marijuana to jury trial procedure and gun-free school zones.<sup>2</sup> The argument is also common in economics and political science. In his classic work on fiscal federalism, Wallace Oates suggested that one of the three main benefits of decentralization is that it may “result in greater experimentation and innovation in the production of public goods.”<sup>3</sup>

This paper reexamines the political economy behind this argument. Why might decentralization increase the frequency of policy experimentation? Some assume that in a centralized system, the government cannot differentiate its policies geographically (e.g. Strumpf 2002). Given this, in a country with 50 regions, a centralized government can conduct only one fiftieth as many experiments per period as regional governments acting autonomously. Brandeis seemed to have this in mind. Federalism, he wrote, permitted “courageous” states to experiment “without risk to the rest of the country,” implying that in non-federal orders experiments would have to impose risks nationwide.

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<sup>1</sup> See Brandeis’ dissent in *New State Ice Co. v. Liebmann* (1932, 285 U.S. 262). In fact, others had expressed similar ideas before; see, for instance, Bryce (1888, p.353, quoted in Oates 1999, p.1132) and Laski (1921, p.52).

<sup>2</sup> On physician-assisted suicide, see Justice O’Connor’s opinion in *Washington v. Glucksberg* (521 US 702, 1997); on medical marijuana, see Justice Stevens in *US v. Oakland Cannabis Buyers’ Cooperative* (532 US 483, 2001); on jury trial procedure, see Justice Powell in *Johnson v. Louisiana* (406 US 356, 1972); on guns in school, see Kennedy in *US v. Lopez* (514 US 549, 1995). These examples are taken from Althouse (2004).

<sup>3</sup> Oates (1972, p.12). See also his discussion in Oates (1999, pp.1131-34).

However, as many scholars have pointed out, centralized governments can implement different policies in different regions, and they do so all the time.<sup>4</sup> Even Stalin's totalitarian regime provided schooling in native languages in the 14 non-Russian Soviet republics (Bilinsky 1968). Among democracies, the United Kingdom and France are considered among the most politically centralized. But both differentiate policies geographically in countless ways. The British operate entire separate legal systems for England and Scotland. In France, even in the 1960s heyday of *dirigisme*, the national economic plan broke down into distinct and varied regional plans (MacLennan 1965).

Local policy experiments occur in both centralized dictatorships and centralized democracies. In the Soviet Union, Brezhnev authorized economic experiments in particular regions, and extended successful ones to other areas.<sup>5</sup> Similar localized experiments occurred in China under both Mao and his successors. Among democracies, the UK central government frequently tests policies in selected local areas before "rolling them out" nationwide. One 2003 survey identified "well over 100" such pilot schemes conducted in the previous five years, and even worried that central authorities might run out of test sites.<sup>6</sup> Experiments examined the effectiveness of financial incentives to keep teenagers in school (in 15 local education authorities), aid to low-income workers (eight pilot areas), anti-smoking initiatives (26 health action zones), personal advisers to help poor single parents get jobs (eight local areas), schemes to improve the real estate market (in Bristol), and treatment and testing sentences for minor drug

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<sup>4</sup> See Breton (1996), Besley and Coate (2003), Seabright (1996, p.63), Brennan and Buchanan (1980, p.174), Oates (1999, p.1133).

<sup>5</sup> One example is that of Georgia under Eduard Shevardnadze in the 1970s. In the backward Abasha region, Shevardnadze "regrouped all agricultural institutions into one management association and introduced a new system of remuneration based on a Hungarian model... The experiment, which resulted in spectacular increases in agricultural production, was extended to other regions of the republic and became the model for so-called RAPOs (agricultural-industrial associations), created at the national level in 1982" (Ekedahl and Goodman 1997, chapter 1). Shevardnadze was also allowed to experiment with commerce, permitting small, family-run private enterprises.

<sup>6</sup> "With the growth in the number of locations that have been selected as either test or control areas for one pilot or another... the supply of suitable 'untouched' localities may soon be exhausted" (Jowell 2003, pp.25, 32).

offenders (in Croydon, Gloucestershire, Liverpool, Glasgow, and Fife).<sup>7</sup> The locations for these experiments were selected to ensure appropriate controls or to examine how policies interacted with local conditions.

Clearly, localized policy experiments are possible under both centralized and decentralized orders. Whether they are more frequent under one than the other needs to be explained, therefore, in terms of the incentives these structures create for the relevant policymakers. Do centralized or decentralized systems motivate officials more strongly to experiment? We develop a model to study this question, focusing on democracies and assuming that citizens vote retrospectively. Risk-neutral, reelection-seeking incumbent officials decide whether to enact “experimental” or “status quo” policies. Experimental policies have payoffs that are not known precisely before they are chosen for the first time; the payoff comes from a known distribution, and is revealed after the policy is enacted. Under “centralization”, a nationally elected official chooses local policies for all units; under “decentralization”, locally elected officials choose policies for their own units. As is standard in retrospective voting models, voters vote for the incumbent if their payoff is above a certain threshold. We derive the equilibrium number of local experiments conducted under each system, given different types of experiments with different distributions of payoffs.

We find that, although there are certain cases in which decentralization results in greater equilibrium innovation, some powerful effects pull in the opposite direction. One, which has been noted before, is the positive *information externality effect*. Because knowledge acquired through one local unit’s experiments benefits others, uncoordinated local governments will tend to underinvest in policy experimentation. A central government will internalize such externalities. Our model reveals two new effects, which follow from the different electoral logic for central and local incumbents—specifically, the fact that a central incumbent must win a majority nationwide,

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<sup>7</sup> See UK Office of the Deputy Prime Minister (2002), Eley et al. (2002), Jowell (2003, pp.18-30).

while each local incumbent must win in its own locality. Whereas the electoral fate of a local incumbent depends entirely on the outcome of policy in its unit, a central incumbent's probability of reelection is a more complicated function of the policy outcomes in all the local units.<sup>8</sup>

This can have two opposite effects. If experiments are sufficiently politically risky, then under decentralization each local government will choose not to experiment, resulting in no experiments nationwide. In the same conditions under centralization, however, the central government would often choose to experiment in a subset of localities. Even if it loses in some, it can still get reelected so long as it gets the votes of others. And successful policies discovered in the experimenting units can be implemented in the others to win the center support there. This *risk-taking effect* suggests that, when experiments are relatively risky, there will be more experimentation under centralization. By contrast, if experiments are sufficiently politically promising relative to status quo policies, under decentralization all local governments choose to experiment. But under centralization, the central government might still prefer to experiment in only a majority of units, holding the others in reserve to implement any successful policies thus discovered. This *risk-conserving effect* suggests that when experiments are relatively politically promising more experiments will be enacted under decentralization than centralization. Putting these together, we show that equilibrium innovation may be greater under decentralization than centralization when policy experiments are extremely politically promising, but that it will be greater under centralization in other cases.

We study several extensions. First, as the number of local units increases, the temptation for local governments to free-ride on others' experimentation under decentralization grows, while the risk-taking and risk-conserving effects under centralization push the central government toward experimenting in half the units. As a result, for a sufficiently large number of localities, centralized governments always experiment more than decentralized ones. Second, when policy

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<sup>8</sup> We assume for simplicity that the minimum scale for implementing a policy experiment corresponds to the local unit. This is not strictly necessary. All one needs is that the national jurisdiction could be divided into more non-overlapping test sites than each local jurisdiction.

experiments are correlated or heterogeneous, decentralization suffers from another kind of coordination failure: all local governments duplicate each other's efforts by choosing the same, most-promising experiment in a given round. By contrast, the central government will coordinate experimentation among local units to increase the chance of discovering successful policies. Third, if policy experimentation imposes negative externalities on other localities, centralization—by internalizing these externalities—often leads to less experimentation. However, preventing such uncompensated cost-exporting will often be desirable.

Several other effects do not fit into the model but are nevertheless important to the comparison. We discuss these at the end of the paper. We conclude that in most regards politically *centralized* governments have stronger incentives to experiment and greater capacity to coordinate experiments and rapidly exploit the knowledge they generate. If states are “policy laboratories”, these laboratories will often be more innovative and better organized if their experiments are centrally authorized and coordinated.

Several previous papers have used formal modeling to explore the relationship between decentralization and experimentation. In a pioneering contribution, Susan Rose-Ackerman (1980) examined the extent of experimentation in decentralized systems. Like us, she found that experimentation by uncoordinated local governments can result in wasteful duplication or free-riding. Our approach differs from hers in that we explicitly model different political incentives to experiment under centralized and decentralized systems of electoral democracy, and contrast the equilibrium outcomes. We reproduce some effects noted by Rose-Ackerman, but identify a number of additional ones (e.g., the risk-taking and risk-conserving effects) and show how these may interact. Strumpf (2002) also identifies the informational externality effect. However, he assumes that central governments cannot enact different policies in different localities. As noted, we consider this unrealistic, and examine the logic that results if the assumption is abandoned. Finally, Kollman, Miller and Page (2000) study the relative effectiveness of policy search in unitary and federated organizations. They model a tradeoff between assigning search to a single,

more sophisticated central organization and assigning it to multiple subunits that can work in parallel, with different strategies. However, since even the most centralized state can instruct its agents to conduct multiple, parallel experiments, using different algorithms, the paper is really about the central government's choice of strategy rather than about comparing political centralization and decentralization per se.

To focus on the direct effects of state structure on policy experimentation, we abstract in our models from various complicating issues. For instance, we abstract from redistribution, both within and across regions. Thus, all residents of a region share the same preferences over local experimentation, and no interregional redistributive transfers are used to finance experiments. We also suppose that governments—both local and central—are unitary actors, and, as already noted, that the voters vote retrospectively, coordinating to reward the relevant incumbent for good performance, whether produced by experimentation or status quo policies.

## 2 The basic model

Consider a state divided into three localities, indexed by  $i$ , each of which contains the same number of voters. Under *decentralization*, all decisions are made by local governments for their own unit; under *centralization*, a single central government makes all decisions for all three units. There are two periods before elections are held (either local elections, under decentralization, or a central election, under centralization.) We assume that each government consists of a single actor and that elections pit the incumbent against a single alternative candidate. To win, the incumbent in a local election must win a majority of votes in his locality; in a central election, the incumbent must win a majority of votes nationwide. Incumbents get a positive payoff from reelection and zero from losing, and so choose policies to maximize their probability of reelection. To focus on just the effects of decentralization on experimentation, we assume that the preferences of all

voters (over outcomes in their own localities) are identical. (For now, we assume no interjurisdictional externalities, but we discuss these later.)

In each period, the appropriate incumbent government chooses a policy for each locality. It can choose the status quo policy,  $A$ , which has consequences that are known to all. Or it can choose an experimental policy,  $E \in \{E_1, E_2, \dots, E_l\}$ , from a set of  $l$  possible experiments, where  $l > 0$  is large. Any experimental policy,  $E_i$ , may have either of two outcomes—“success” or “failure”. The outcome is not known in advance, but all know the probability of “success”,  $q_i$ , where  $0 < q_i < 1$ . We normalize so that the per-period payoff of  $A$  to the local representative voter is zero. The per-period payoff of implementing  $E_i$  if  $E_i$  “fails” is  $-F_i$ ; if  $E_i$  “succeeds”, the per-period payoff is  $S_i$ ; where  $F_i, S_i > 0$ . We assume for now—and relax this later—that each of the  $l$  possible experiments has the same probability of success,  $q$ , and the same payoffs for “success” and “failure” ( $S$  and  $F$  respectively.) Thus, each experiment has the same expected value. We also assume for now—and relax the assumption later—that the outcomes of different experiments are independent. At the beginning of the second period, all localities observe the outcomes of all policy experiments conducted in the first period. Thus, if any successful experiment was implemented in the first period, all will implement a successful experiment in the second.

The voters vote retrospectively, responding to performance rather than to the policy choice.<sup>9</sup> At the end of the second period, the representative voter in each locality votes for the

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<sup>9</sup> Thus, policymakers are not given credit by the voters for choosing experiments that have a positive ex ante expected value but which in fact fail. Alternatively, one could model the voters’ strategy as one of rewarding incumbents for picking the options with the highest ex ante expected value. However, assuming retrospective voting based on some broad measure of performance is more consistent with a view of voters as “rationally ignorant” about the details of policy, and seems closer to the stylized facts of actual voting in countries such as the US. Such models were first developed by Barro (1973) and Ferejohn (1986), and inform the extensive literature on political business cycles (Alesina et al. 1997). Empirical studies since Kramer (1971) and Fair (1978) have found strong evidence of retrospective voting in the US.

incumbent if  $u_1 + \mathbf{d}u_2 \geq \bar{u}$ , where  $u_j$  is the voter's payoff in period  $j \in \{1,2\}$ ,  $\bar{u}$  is some predetermined threshold, and  $\mathbf{d} > 0$  is a weight representing the extent to which the voter focuses on the recent past relative to the more distant past. Thus,  $\mathbf{d}$  might represent a discount factor (think of the voters pledging at the beginning of period 1 to reelect the incumbent if and only if she provides them a certain level of utility during her term of office; from the perspective of the start of the term, voters might discount utility experienced toward the end of the term.) If we think of voters deciding how to vote only at the time of election, it is psychologically plausible that they would give greater weight to the recent past ( $\mathbf{d} > 1$ ). Considerable empirical evidence suggests that US voters vote retrospectively in presidential elections, focusing on economic performance in the last few quarters before the ballot. Such a focus can also be rationalized as in Rogoff (1990). If one period lasts longer than the other, this could also be captured in  $\mathbf{d}$ . So the representative voter's total payoff is: zero if policy  $A$  is implemented in both periods,  $(1 + \mathbf{d})S$  if successful experiments are implemented in both periods,  $-\mathbf{d}F$  if  $A$  is implemented in the first period and a failed experiment in the second period, and so on.

By the assumptions of retrospective voting, the probability that voters in a given locality vote for the incumbent must be non-decreasing in the representative voter's payoff. For simplicity, we assume that voters vote against the incumbent if their total payoff in the two periods is strictly less than zero,  $u_1 + \mathbf{d}u_2 < \bar{u} = 0$ . So implementing failed experiments in both periods, or a failed experiment in one period and policy  $A$  in another, results in rejection of the incumbent by voters in the relevant locality. We also assume that the voters vote for the incumbent for sure if the policy is  $E$  in both periods and the experiment succeeds, that is if  $u_1 + \mathbf{d}u_2 = (1 + \mathbf{d})S$ . Denote the probability that voters vote for the incumbent if he adopts policy  $A$  in both periods,  $p_0$ , and the probability they vote for him if the policy is  $A$  in the first period and  $E$  in the second and the experiment succeeds,  $p_1$ . Then  $0 \leq p_0 < p_1 < 1$ . The parameter  $p_0$

can be interpreted as an incumbent’s opportunity cost of experimenting. In our model,  $p_1$  can be thought of as a measure of information externalities because a local incumbent has a stronger incentive to wait and free-ride on the experiments of others when  $p_1$  is larger.

In this setup, we can distinguish several types of experiment. We emphasize two distinctions. One kind of experiment has a relatively high cost of failure,  $F$ . One might think of deregulating electricity generation, where “failure” would result in widespread blackouts, or building a new kind of nuclear power plant, where “failure” could mean serious, long-lasting health risks to the population. We call such cases “high stakes experiments”.<sup>10</sup> Despite the high cost in the event of failure, high stakes experiments may often be worth doing: if the probability of failure is sufficiently low and the benefits of success sufficiently high, the expected value may be positive and large. More specifically, we say an experiment is a “high stakes” one if  $dS < F$ . If the incumbent implements a high stakes experiment in the first period and it fails, he has no chance of winning back the voters affected by implementing a successful experiment in the second. By contrast, if the incumbent implements a “low stakes” experiment in the first period ( $dS \geq F$ ) and it fails, the incumbent can still get reelected if he implements a successful experiment in the second period. Examples of “low stakes” experiments might include increasing car registration fees to pay for road maintenance or investing in an advertising campaign to promote water conservation. Let  $\tilde{p}$  be the probability that voters will vote for the incumbent if he implements a failed “low stakes” experiment in the first period but a successful experiment in the second. Clearly,  $p_0 \leq \tilde{p} < p_1$ .

For a given set of payoffs to the voters for success or failure, a second distinction concerns the experiment’s probability of success,  $q$ . From the incumbent government’s perspective, what matters is the probability of experiments’ success relative to the probability of

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<sup>10</sup> The term is slightly unfortunate in that what matters here is just the cost of failure rather than the payoff of success. We could not find another word that fits better.

getting voters' support without experimenting,  $p_0$ . When  $q$  is high relative to  $p_0$ , we say that experiments are “politically promising”. If  $q$  is sufficiently high relative to  $p_0$ , all incumbents will always choose to experiment in the first period. When  $q$  is low relative to  $p_0$ , we say experiments are “politically risky”. If  $q$  is sufficiently low relative to  $p_0$ , incumbents will never experiment at all.

Under decentralization, the three local governments decide their policies in each period non-cooperatively and simultaneously. We focus on the symmetric subgame perfect equilibrium of this game. Under centralization, in each period the central government decides which policies to implement in each locality. By comparing the equilibrium number of local experiments under decentralization and centralization, we derive implications about when centralization results in greater policy experimentation than decentralization.

### 3 High stakes experiments

When experiments carry “high stakes” ( $dS < F$ ), any units where failed experiments are enacted in the first period vote against their incumbent for sure. If at least one successful experiment occurs in the first period, then all units that had  $A$  or a successful experiment in the first period will implement a successful experiment in the second. If no locality had a successful experiment in the first period, then those that had  $A$  in the first period experiment in the second if  $qp_1 \geq p_0$  and implement  $A$  again in the second if  $qp_1 < p_0$ . Since all governments maximize reelection probabilities, the second period choices described here apply to both decentralization and centralization.

Under centralization, let  $k \in \{0,1,2,3\}$  be the number of localities in which the central government chooses experiments in the first period. Note that since experiments have the same payoffs and are independent, if the central government chooses more than one experiment in any

period, it will choose different experiments in different localities. Its expected payoff, i.e., its probability of winning reelection in at least two localities, is given by

$$U = \begin{cases} 3w^2 - 2w^3, & \text{if } k = 0; \\ q(2p_1 - p_1^2) + (1-q)w^2, & \text{if } k = 1; \\ q^2 + 2q(1-q)p_1, & \text{if } k = 2; \\ 3q^2 - 2q^3, & \text{if } k = 3. \end{cases} \quad (1)$$

where  $w = \max\{qp_1, p_0\}$  is the probability that a locality's voters vote for the central incumbent if the locality has  $A$  in the first period and no successful experiment is discovered in the first period by others.

Under decentralization, a local incumbent's expected payoff (i.e., probability of reelection) from experimenting in the first period is  $q$ . If he chooses policy  $A$ , his expected payoff is  $w = \max\{qp_1, p_0\}$  if  $j = 0$ ;  $qp_1 + (1-q)w$  if  $j = 1$ ; and  $(2q - q^2)p_1 + (1-q)^2w$  if  $j = 2$ ; where  $j$  is the number of other localities that choose to experiment in the first period.

### 3.1 Politically risky experiments

When experiments are sufficiently politically risky,  $q \leq p_0$ , under decentralization choosing policy  $A$  is a strictly dominant strategy for incumbents in all localities. So no policy experimentation occurs under decentralization.

Under centralization, the central government's expected payoff is given by Equation (1) with  $w = p_0$ . We have the following result (all technical proofs are in Appendix 1.)

**Proposition 1.** Suppose  $dS < F$  and  $q \leq p_0$ . Under decentralization no locality chooses policy  $E$ . Under centralization, the central government will choose  $E$  in one or two of the three localities in the first period as long as  $p_0 \leq \mathbf{r}(p_1, q)$ , where  $\mathbf{r}(p_1, q) \in (q, 1]$  is increasing in  $p_1$  and  $q$ .

Proposition 1 says that high stakes, politically risky policy experiments will not be undertaken under decentralization, but will be undertaken under centralization so long as the incumbent's reelection is not too secure under the status quo. The case of politically risky experiments shows two ways in which centralization facilitates policy experimentation. The first advantage is a familiar one—the *information externalities effect*. Local policy experimentation generates information that has positive externalities for other localities. Local governments under decentralization ignore such externalities. But under centralization, the central government internalizes them. It will therefore be more willing to experiment than local governments, and the center's motivation to experiment will increase with the size of the externalities. In our model, the information externalities are greater, the larger is  $p_1$ . As Proposition 1 shows, for given  $p_0$  and  $q$ , the central government is more likely to undertake policy experimentation when  $p_1$  is greater.

A second advantage of centralization is the *risk-taking effect*. For politically risky experiments, a local government that experiments under decentralization knows failure will mean certain defeat at the polls. But under centralization the central government can win reelection even if a policy experiment in one locality turns out to be a failure. It will be willing to take this risk, so long as the informational externalities are large enough and the opportunity cost of experimentation,  $p_0$ , is not too high. To give a concrete example, suppose  $q = 0.3$ ,  $p_0 = 0.4$ ,  $p_1 = 0.8$ . From Equation (1), the central government's expected payoff is 0.352, 0.4, 0.345, 0.216, when it chooses policy  $E$  in 0, 1, 2, or 3 localities, respectively. Thus the

central government's optimal strategy is to choose policy  $E$  in one locality. In this case, the central government's reelection probability, 0.4, is greater than  $q = 0.3$ , the reelection probability of an incumbent in any locality choosing policy  $E$ . Choosing policy  $E$  in one locality, the central government will get reelected with a probability of  $0.3 \times (1.6 - 0.64) = 0.288$  if the experiment is successful. But the central government will also get reelected with a probability of  $0.7 \times 0.4 \times 0.4 = 0.112$  even when the experiment fails, since it still has a chance of winning in the other two localities.

Proposition 1 shows that, contrary to the common view that decentralization is generally better at promoting policy experimentation, centralization leads to no less, and likely more, policy experimentation than decentralization when policy experiments are both high stakes and politically risky. While a case in which local governments conduct no policy experiments under decentralization may seem a little extreme, we demonstrate below that the main insight is quite general.

### 3.2 Politically promising experiments

When experimenting is sufficiently politically promising,  $q > p_0$ , the following lemma presents the central government's optimal experimenting strategy.

**Lemma 1.** *Suppose  $dS < F$  and  $q > p_0$ . Under centralization, the central government chooses policy  $E$  in the first period in all three localities when  $p_1 \leq q$ , and experiments in two of the three localities when  $p_1 > q$ .*

Since the central government needs to win at least two localities and experimenting is promising, it will experiment in at least two localities in the first period. When  $p_1$  is greater than

$q$ , it is better to have one locality enact policy  $A$  and wait to see the outcomes of experiments in the other two localities. When  $p_1$  is less than  $q$ , waiting provides no benefit, so the central government experiments in all three localities.

For promising policy experimentation, the following lemma characterizes the unique symmetric equilibrium under decentralization.<sup>11</sup>

**Lemma 2.** *Suppose  $dS < F$  and  $q > p_0$ . Under decentralization, there is a unique symmetric equilibrium. When  $p_1 \leq q$  or  $q(2-q)p_1 \leq q - (1-q)^2 w$  (where  $w = \max\{qp_1, p_0\}$ ), all localities choose policy  $E$  in the first period. Otherwise, each locality chooses policy  $E$  in the first period with probability  $\mathbf{b} = \frac{1}{q} - \frac{1}{q} \left( \frac{p_1 - q}{R - w} \right)^{1/2}$ .*

The intuition for Lemma 2 is as follows. Since  $q > p_0$ , a locality would choose to experiment by itself in the first period if no other localities do so. Hence, in equilibrium all localities experiment in the first period with positive probabilities. But if other localities experiment in the first period, a given locality has an incentive not to experiment so as to free-ride on the discoveries of others. Such incentives to free-ride are stronger when  $p_1$  is higher. From Lemma 2, it is easy to see that as  $p_1$  increases, the equilibrium probability of localities experimenting in the first period,  $\mathbf{b}$ , decreases. In addition, in equilibrium the incumbents choose policy  $E$  with a greater probability when  $q$  is larger or when  $p_0$  is smaller (if  $q > p_0 \geq qp_1$ , so that  $w = p_0$ ). When  $q(2-q)p_1 \leq q - (1-q)^2 w$ , then all localities choose

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<sup>11</sup> Under certain parameter values, the game under decentralization can have asymmetric pure strategy equilibria in which one or two localities choose policy  $E$  while the rest choose policy  $A$ . Focusing on such equilibria, we obtain qualitatively similar results, but at the cost of more tedious analysis.

policy  $E$  with probability one. Suppose  $qp_1 \geq p_0$  so that  $w = qp_1$ . Then all localities choose policy  $E$  with probability one when  $p_1 \leq 1/(3 - 3q + q^2)$ .

From Lemma 2, the expected number of localities choosing policy  $E$  under decentralization is  $3b$ . From Lemmas 1 and 2, when  $p_1 \leq q$ , policy  $E$  is implemented in all localities under both decentralization and centralization. When  $p_1 > q$ , we can show the following result.

**Proposition 2.** *Suppose  $dS < F$  and  $p_0 < q < p_1$ . Compared with the expected number of localities choosing policy  $E$  in the symmetric decentralization equilibrium, centralization leads to more policy experimentation if and only if  $4q(3 - q)p_1 + (3 - 2q)^2 w > 9q$ .*

Proposition 2 shows that when policy experiments are high stakes and politically promising, centralization can lead to more experimentation than decentralization under plausible conditions. This will tend to occur when  $p_1$  is relatively high so that local governments under decentralization have strong incentives to free-ride on the experimentation of others.<sup>12</sup> The central government internalizes the information externalities, and thus has a stronger motivation to experiment.

But unlike in the case of politically risky experiments, decentralization can lead to greater experimentation under certain conditions. If incentives to free-ride are weak (i.e.,  $p_1$  is relatively low), all three localities choose policy  $E$  with high probability under decentralization. By contrast, so long as  $p_1 > q$ , the central government would choose to experiment in only two localities and keep the other in reserve to implement any successful experiment discovered in period 1. So,

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<sup>12</sup> The left-hand side of  $4q(3 - q)p_1 + (3 - 2q)^2 w > 9q$  increases in  $p_1$ . In the case of  $qp_1 > p_0$ , the condition in Proposition 2 becomes  $p_1 > 9/(21 - 16q + 4q^2)$ .

when experimentation is politically promising, there will be an intermediate range of  $p_1$  in which more experimentation occurs under decentralization than under centralization.<sup>13</sup> In this case, the central government's ability to economize on risk-taking causes it to experiment less.

Summarizing Propositions 1 and 2, we see that the fact that the central government competes nationwide for votes implies three effects for policy experimentation. The *information externalities effect* motivates the central government to experiment more than the local governments because it can benefit more from discoveries. The *risk-taking effect* also motivates the central government to experiment in some localities even when the chance of success is relatively low, because it can still win reelection even if an experiment fails in one locality. We call the third effect the *risk-conserving effect*. When the chance of experiments succeeding is in an intermediate range, the central government prefers to experiment in just two localities and keep the third in reserve to implement successful discoveries. By contrast, under decentralization all three local governments would experiment with high probability, yielding an expected number of experiments greater than two.

## 4 Low stakes experiments

When experiments have low stakes ( $dS \geq F$ ), an incumbent still has a chance of winning back voters who are upset about a failed experiment in the first period. If she implements a failed experiment in period 1 but a successful experiment in period 2, her chance of winning majority support in that locality is  $\tilde{p}$ , where  $p_0 \leq \tilde{p} < p_1$ . Since an incumbent who fails the first time gets a second chance, we expect to see more policy experimentation under both decentralization and centralization than in the case of high stakes experiments. The interesting question is whether results similar to those in Propositions 1 and 2 still hold.

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<sup>13</sup> If  $qp_1 \leq p_0$ , this range is  $q < p_1 < [9q - (3 - 2q)^2 p_0] / [4q(3 - q)]$ ; if  $qp_1 > p_0$ , the range is  $q < p_1 < 9 / (21 - 16q + 4q^2)$ .

We demonstrate in Appendix 2 that they do. When experiments are sufficiently politically risky, no experimentation occurs under decentralization, but the central government does experiment under centralization so long as externalities are sufficiently strong ( $p_1$  relatively high). When experiments are sufficiently politically promising, then centralization leads to greater experimentation (under certain conditions) when  $p_1$  is relatively high. On the other hand, due to the risk-conserving effect under centralization, decentralization can promote more experimentation than centralization under certain conditions when  $p_1$  is relatively low. The main insights of our model hold whether policy experiments are high stakes or low stakes.

## 5 Extensions

We study here several extensions of the basic model, focusing on high stakes experiments in order to save space. Similar results also hold for low stakes experiments.

### 5.1 A large number of localities

Increasing the number of localities has two effects, both of which tend to produce greater experimentation under centralization. First, the risk-taking effect gets stronger. The central government needs only to win support of voters in a majority of localities. As the number of units increases, the importance of each to the center's winning coalition declines. The center will be more willing to risk failure in a number of localities in order to find successful policies that can be implemented in the others. By contrast, under decentralization each local government must win a majority within its own jurisdiction, and this does not change as the number of localities grows. Second, as the number of localities increases, the incentive for individual localities under decentralization to wait and free-ride on others' discoveries increases. This also reduces the motivation of individual localities to experiment.

To see the logic, suppose there are  $n$  identical localities, where  $n$  is an odd, large number. Consider first experiments that are politically risky,  $q < p_0$ . In this case, choosing the status quo,  $A$ , is a dominant strategy for each locality under decentralization, and no experimentation occurs. By contrast, under centralization the central government will order some experiments so long as  $p_0$  is relatively small and  $p_1$  is relatively large. In the limit, as  $p_1$  approaches one, the number of experiments chosen by the central government will approach  $(n-1)/2$ . Any successful policy thus discovered can then be implemented in period 2 in the  $(n+1)/2$  localities held in reserve, almost surely winning the incumbent a nationwide majority since  $p_1$  is very close to 1. Whereas individual local governments will not risk experimenting at all, a central government would experiment in almost half the localities when  $p_1$  is high, even if the probability of any given experiment succeeding is small. This is the risk-taking effect at work.

What if experiments are politically promising? If the chance of experiments succeeding is very high ( $q \geq p_1$ ), then experiments occur in every locality under either decentralization or centralization. If experiments are politically promising, but not quite so likely to succeed ( $p_0 \leq q < p_1$ ), then as  $n$  gets large, centralization again outperforms decentralization. We can prove the following result as  $n$  approaches infinity.

**Lemma 3.** *Suppose  $p_0 \leq q < p_1$  and let  $n \rightarrow \infty$ . Under decentralization, the probability of each locality choosing policy  $E$  in the first period in the symmetric equilibrium goes to zero. The expected number of localities choosing policy  $E$  in the first period converges to*

$$m^* = \frac{\ln(p_1 - q) - \ln(p_1 - w)}{\ln(1 - q)}.$$

*Under centralization, the central government chooses policy  $E$  in an unbounded number of localities as  $n \rightarrow \infty$ .*

The probability of any given locality experimenting under decentralization goes to zero as  $n$  increases because each locality wants to free-ride on discoveries of others, and the free-rider problem becomes worse as the number of localities rises. The expected number of experiments under decentralization converges to a constant independent of  $n$ . But under centralization, the expected number of experiments increases with  $n$  without bound. Summarizing the discussion about both politically risky and promising experiments, we have the following conclusion.

**Proposition 3.** *When the number of localities becomes sufficiently large, centralization leads to more policy experimentation than decentralization.*

## 5.2 Correlated experiments

In the basic model we assume that politicians choose from a large number of policy experiments, each of which has the same benefits if successful, costs if unsuccessful, and probability of success. We also assume that the results of all experiments are independent. But often these assumptions will not hold. We first examine what happens if the results of experiments are not independent. For instance, some types of experiment involve choosing different points on a scale. Suppose the speed limit on highways is 65 miles per hour. One locality might reduce its speed limit to 55 miles per hour to see how this affects traffic accidents, another to 45 miles per hour, and so on. The results would likely be correlated, though less than perfectly.

To analyze correlated experiments, we consider the simplest case, in which there is only one available experiment. All localities that experiment implement this policy and have the same outcome. Furthermore, once any locality implements this policy in the first period, other localities

that do not implement it in the first period will all implement it in the second period if it is successful and will all choose policy  $A$  otherwise.<sup>14</sup>

**Proposition 4.** *For perfectly correlated experiments, centralization implements policy  $E$  in as many or more localities than decentralization unless  $p_0 + p_1 > 1$  and*

*$p_0 / (1 - p_1 + p_0) \leq q < p_0^2 / [(1 - p_1)^2 + p_0^2]$ . Under centralization, the probability of discovering a successful policy is always at least as great as—and sometimes greater than—under decentralization.*

Thus, for perfectly correlated experiments, we get qualitatively the same results as we did in Propositions 1 and 2 for independent experiments. When the two conditions in Proposition 4 hold, all three localities choose to experiment under decentralization but only one is chosen to experiment under centralization. However, because of the perfect correlation, the probability of discovering a successful policy is the same under both systems. In other non-trivial cases, the central government chooses policy  $E$  in at least one locality under centralization, while the expected number of localities choosing policy  $E$  under decentralization is less than one.<sup>15</sup> Therefore, in terms of promoting effective policy experimentation, the case for centralization is stronger than when experiments are independent because the probability of discovering a successful policy under centralization is always equal to or greater than that under decentralization. Similar conclusions should hold for highly, but imperfectly, correlated experiments.

When experiments are not perfectly correlated, centralization may have another benefit. Consider the example of choosing different speed limits to examine the effect of this on traffic

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<sup>14</sup> In this case there is no “low stakes” experiment as analyzed before, since a locality does not have any other experiment to implement after its experiment in the first period fails.

<sup>15</sup> In the trivial case, no experiment is implemented under centralization and decentralization.

accidents. The amount of information that results from a given number of experiments will depend on how the different “treatments” are selected. A central government choosing  $k$  experiments would probably choose speed limits spaced across the relevant range on the scale, making it easier to plot the relationship. Under decentralization, local governments choosing experiments in an uncoordinated way may duplicate each other’s choices or bunch around certain values, making it harder to estimate the relationship with confidence. This *calibration effect* would tend to render correlated experiments under centralization more informative.

### 5.3 Heterogeneous experiments

We now relax the assumption that all policy experiments have the same costs of failure, benefits of success, and probability of success. Suppose there is one policy experiment  $E_0$  with success probability of  $q$  and many other experiments with success probability of  $\hat{q} < q$  (call these “lower-odds experiments”). All experiments are statistically independent.

Under decentralization, if any locality experiments in the first period, it will always choose  $E_0$  because this strictly dominates choosing any other experiment. When  $\hat{q}p_1 \leq p_0$ , no locality will implement a lower-odds experiment in the second period if no successful experiments were implemented in the first. This means lower-odds experiments will never be implemented. The equilibrium outcome is exactly the same as if policy  $E_0$  were the only experiment option; our analysis of perfectly correlated experiments in the preceding subsection applies here. In the pure strategy equilibrium, either zero, one, or three localities choose policy  $E_0$ , depending on parameter values. But even when all three localities conduct policy experiments, they all choose the same policy  $E_0$ . Other experiments will never be tried. Thus, individual localities fail to coordinate and duplicate each others’ efforts, even when there exist other viable experiments with quite good chances of success and positive expected value. When  $\hat{q}p_1 > p_0$ , all localities that choose policy  $A$  in the first period do enact lower-odds experiments in

the second period if  $E_0$  was tried and failed in the first. The equilibrium analysis resembles that of the basic model, and the equilibrium outcome converges to that in Lemma 2 as  $\hat{q} \rightarrow q$ .

Under centralization, the central government does not suffer from the kind of coordination failure that occurs under decentralization leading all experimenting localities to choose the same policy. To see the contrast most clearly, consider the case in which other policy experiments are almost as good as  $E_0$ , i.e.,  $\hat{q} \rightarrow q$ .<sup>16</sup> Then the central government's payoff function is given by Equation (1), and its optimal solution is the same as in Section 3. When  $\hat{q}p_1 > p_0$ , we then obtain the same results as in Section 3. When  $\hat{q}p_1 \leq p_0$ , we obtain the following result very similar to Proposition 4.

**Proposition 5.** *Suppose  $\hat{q}$  is sufficiently close to  $q$  and  $\hat{q}p_1 \leq p_0$ . Centralization implements policy experiments in as many as or more localities than decentralization unless  $p_0/(1 - p_1 + p_0) \leq q < p_1$ . Under centralization, the probability of discovering a successful policy is always at least as great as—and sometimes greater than—under decentralization.*

Thus, when experiments are heterogeneous, centralization will often do better than decentralization at stimulating the discovery of successful policies. Under decentralization, experiments with positive expected value may be neglected due to the coordination failure that leads all experimenting localities to choose the same experiment. Under centralization, the central government orders different experimenting localities to choose different policies to maximize the chance of success.

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<sup>16</sup> At the other extreme, if  $\hat{q} \rightarrow 0$ , then we are back to the case of perfectly correlated experiments.

## 5.4 Negative externalities

One of the main advantages of centralization is that it can internalize the positive informational externalities of localized experiments. But the externalities associated with local experiments can also be negative. Suppose that experiments impose costs not just on the experimenting locality but on its neighbors as well. For instance, local governments might reduce pollution controls to see if this attracts investment, or reduce welfare payments to the unemployed, prompting them to move. Clearly, a central government that internalizes such externalities will, for this reason, enact fewer of this type of experiment than local governments that can export such costs. Since the central incumbent must get votes in more than one locality, it will often care about the negative effects that cross local borders. Equally clearly, if the external costs of such experiments are high, preventing such experiments will increase social welfare, understood as the sum of the payoffs to the representative voters in each locality.

One kind of interregional externality merits separate consideration. Suppose that voters care about what policies are enacted not just in their own locality but in other localities too. In the US, for instance, many voters care strongly about whether abortion is legal not just in their own state but in other states as well. Voters might care about policy in other localities because they anticipate moving to them. Or they might simply wish to impose their moral or ideological values on others. If such external costs and benefits inform voting in other localities, then the central government will take them into account; it may not choose to implement locally popular policies that alienate voters elsewhere. Banning abortion in Alabama might win the central government votes there, but lose it even more in California.<sup>17</sup> This might reduce the number of experiments under centralization.

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<sup>17</sup> Central governments might also be more vulnerable to the pressures of national interest groups such as labor unions or business confederations. Such groups might favor uniform policies for their members nationwide. This also might lead central governments not to choose policies preferred by the local majorities in all cases. However, there is no clear reason why national interest groups in a decentralized system would not be able to lobby the individual local governments just as they lobby the central

Although such “ideological spillovers” may be important, they may not imply a great innovation advantage for decentralization in practice. First, the institutions guaranteeing local autonomy must be quite robust to resist the pressure of national public opinion. Even in countries with very decentralized constitutions, central authorities and national judiciaries often intervene to overrule subnational governments whose policies conflict with preferences of the national majority. The US is among the most decentralized countries in the world. Its Supreme Court regularly uses the Commerce Clause, the 8<sup>th</sup> Amendment, and Section 5 of the 14<sup>th</sup> Amendment to invalidate state laws on various grounds, often explicitly rejecting the “states as laboratories” argument—as, of course, the majority did in *New State Ice Co. vs. Liebmann*. To overturn state policies on grounds of “cruel and unusual punishment”, the Court has explicitly invoked “evolving standards”, based on its perception of nationwide public opinion. So ideological spillovers may restrain unpopular experiments even in decentralized states. Second, if a given experiment is ideologically opposed by the nationwide majority, the potential for it to spread, if successful, is limited. Were a US municipality able to experiment with legalizing heroin and found that drug overdoses fell, it seems doubtful that many other cities would follow. The type of experiment that centralization limits under this argument is precisely a type of experiment that will generate the smallest benefits nationwide.

## 6 Discussion

Several additional effects are not easily incorporated into the model, but affect the comparison between centralization and decentralization in important ways. A first *communication effect* concerns not how frequently experiments occur but how effectively the resulting discoveries are analyzed, transmitted, and exploited. The process of information dissemination likely exhibits economies of scale. It may be cheaper for the central government to consolidate reports of

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government in a centralized state. Indeed, their threats to punish individual local governments with boycotts, etc., might be more credible than threats to stage nationwide strikes or other actions.

different local experiments and communicate these to local governments than for each local government to obtain results of all the other local experiments and perform its own analysis. Even if experimentation decisions are made by local governments, the central government might still choose to perform this public service. But it would certainly do so if it had itself designed the experiments. For this reason, John Stuart Mill argued for a vigorous central government in *On Representative Government*: “The principal business of the central authority should be to give instruction, of the local authority to apply it. Power may be localized, but knowledge, to be most useful, must be centralized; there must be somewhere a focus at which all its scattered rays are collected, that the broken and coloured lights which exist elsewhere may find there what is necessary to complete and purify them” (Mill 1991, p.424).

Collecting and disseminating information about local experiments may not be just a technical matter. One can imagine settings in which voters do not directly observe what policy is enacted, but only the resulting performance. Suppose a local government implements a new procedure for tracking waste within the local bureaucracy, and this procedure turns out to reduce costs substantially. All observe the positive results of this experiment. In theory, the same procedure could be introduced in other localities as well. But suppose now that the local incumbent under decentralization can keep key elements of the procedure secret (perhaps it requires particular software.) If local governments are elected (*decentralization*), it may make sense for local voters to evaluate their performance *relative* to that in neighboring localities (i.e. using “yardstick competition”).<sup>18</sup> If so, then the local government under decentralization will have an incentive *not* to communicate details of its successful experiment because when other units implement the innovation this will erode the first government’s relative performance. Under centralization, no such problem arises (unless the central government also uses yardstick competition to reward its agents and cannot order them to reveal details of policy.) Thus, the

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<sup>18</sup> See Shleifer (1985), Besley and Case (1995).

dissemination of discoveries from policy experimentation may be more rapid under centralization, for strategic as well as technical reasons.

A third issue concerns policy experiments that are not local but national in scope. So far this paper has focused on experiments that can be conducted within a given locality. But some—for instance, experimental foreign policies—can only be carried out within or for the whole country. Whether experimenting on such issues is easier or harder under centralization or decentralization depends on what institutional arrangements exist under decentralization. (Our previous characterization of the two systems is no longer sufficient.) If under decentralized government, central policies must win support of not just a majority of citizens but also majorities within the subunits (that is, each unit has a veto), then enacting nationwide experiments will generally be harder under decentralization than under centralization (assuming this means that only support of a nationwide majority is required.)

Another possible extension concerns heterogeneity not of policies but of localities. Suppose that some localities are less risk averse than others. Or suppose that voters care not just about the “success” or “failure” of particular experiments, but about the policies themselves. Voters in a “left-wing” locality might have a higher payoff from experimenting with universal health insurance—whether it succeeds or fails in saving money—than voters in a “right-wing” locality. By contrast, voters in a “right-wing” unit might have a higher payoff from experimenting with harsh criminal penalties than those in “left-wing” units. It is tempting to think this might lead to greater experimentation under decentralization, since the left-wing units could choose “left-wing” experiments while the “right-wing” units choose “right-wing” ones. But this implicitly assumes that central policies must be uniform, a position we argued is unrealistic. If central incumbents can differentiate policies geographically—and assuming no externalities like

those in Section 5.4—they too would provide left-wing experiments in left-wing units and right-wing experiments in right-wing localities.<sup>19</sup>

Finally, it is useful to consider the implications of the paper’s analysis for social welfare, which we define as the sum of the representative voters’ expected payoffs in the three localities over the two periods. Clearly, the welfare comparison between centralization and decentralization will be indeterminate in general. The politicians care only about their probabilities of reelection, which are not sensitive to the relative voter payoffs from successful and failed experiments. From the point of view of social welfare, there can be “too much” experimentation as well as “too little” under both centralization and decentralization. Thus, findings about the relative amount of experimentation under the two systems do not imply any general results about welfare under the two systems. Suppose, for instance, that no experimentation occurs under decentralization but the central government implements policy  $E$  in one locality in the first period under centralization (as described in Proposition 1.) By our social welfare function, the total social surplus is zero under decentralization, and  $(1+3d)qS - (1-q)F$  under centralization. If the representative voter’s loss from a failed experiment is relatively small ( $F \leq \frac{(1+3d)q}{1-q} S$ ), then centralization—by stimulating greater experimentation—yields greater social surplus. But if the loss from a failed experiment is large, decentralization—by reducing experimentation—results in greater surplus.

## 7 Conclusion

If central governments can enact geographically differentiated policies, then whether centralization or decentralization stimulates policy experimentation must depend on the incentives for officials under the two arrangements. We examined the political economy of this

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<sup>19</sup> Heterogeneity of localities may also limit the potential benefits of local experimentation. As Susan Rose-Ackerman (2000, p.18) points out: “A successful experiment in bilingual education in Texas will not be of much interest in Montana. A new way of teaching girls in a community of Islamic fundamentalists will be of no interest to a neighboring Christian community.”

question, using a retrospective voting model. The common belief that political decentralization is more conducive to policy innovation was not borne out in general. Under certain circumstances, decentralization can result in greater policy experimentation. Local governments facing electorates discontented with the status quo will sometimes all gamble and implement novel policies, while in the same conditions a central incumbent would restrict its risk-taking to a subset of localities. If local experiments have large negative interregional externalities, decentralization may again lead to more experimentation than centralization, although such externalities may result in lower social welfare. In many other circumstances, however, centralization will lead to greater policy experimentation—because of the informational externalities of local experiments or the lower risk of local experiments for reelection-seeking central incumbents. Centralization may also lead to better design of experimental programs, coordination of experiments, and dissemination of the results.

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## Appendix 1: Proofs

**Proof of Proposition 1:** When  $p_0 \geq q > qp_1$ ,  $w = p_0$ . Clearly  $U(k=3) \leq U(k=0)$ . Note that  $U(k=0)$  is strictly increasing in  $p_0$  and  $U(k=2)$  is independent of  $p_0$ . At  $p_0 = q$ , it can be checked that  $U(k=0) < U(k=2)$ . On the other hand, at  $p_0 = p_1$ , it is easy to verify that  $U(k=0) \geq U(k=2)$ . Thus, there exists a threshold value of  $\mathbf{r}_2(p_1, q)$ , such that  $U(k=0) < U(k=2)$  as long as  $p_0 \leq \mathbf{r}_2(p_1, q)$ . Since  $U(k=2)$  is increasing in  $p_1$  and  $q$ , hence  $\mathbf{r}_2(p_1, q)$  is increasing in  $p_1$  and  $q$ .

Similarly, it can be shown that  $U(k=1) - U(k=0)$  is strictly decreasing in  $p_0$ , and is positive at  $p_0 = q$  and negative at  $p_0 = p_1$ . Thus, there exists a threshold value of  $\mathbf{r}_1(p_1, q)$ , such that  $U(k=0) < U(k=1)$  as long as  $p_0 \leq \mathbf{r}_1(p_1, q)$ . The function  $\mathbf{r}_1(p_1, q)$  is also increasing in  $p_1$  and  $q$ .

Let  $\mathbf{r}(p_1, q) = \max\{\mathbf{r}_1(p_1, q), \mathbf{r}_2(p_1, q)\}$ . Then, as long as  $p_0 \leq \mathbf{r}(p_1, q)$ , the optimal  $k$  for the central government is either 2 or 1. ***Q.E.D.***

**Proof of Lemma 1:** When  $p_0 < q$ , clearly  $U(k=3) > U(k=0)$ . It can be checked that

$$U(k=3) - U(k=2) = 2q(1-q)(q - p_1)$$

Hence  $U(k=3) \geq U(k=2)$  if and only if  $q \geq p_1$ . Furthermore, when  $p_0 \leq qp_1$ , we have

$$\begin{aligned} U(k=2) - U(k=1) &= q^2 - 2q^2 p_1 + qp_1^2 - (1-q)(qp_1)^2 \\ &= q^2(1-p_1)^2 + qp_1^2(1-q)^2 > 0 \end{aligned}$$

When  $qp_1 < p_0 < q$ , then

$$\Delta = U(k=2) - U(k=1) = q^2 - 2q^2 p_1 + qp_1^2 - (1-q)p_0^2$$

Since  $\partial\Delta/\partial p_1 = -2q^2 + 2qp_1 = 2q(p_1 - q)$ , so  $\Delta$  is increasing in  $p_1$  when  $p_1 \geq q$  and is decreasing in  $p_1$  when  $p_1 < q$ . Thus, as a function of  $p_1$ ,  $\Delta$  reaches its minimum at  $p_1 = q$ . So we have

$$\Delta \geq q^2 - 2q^3 + q^3 - (1-q)p_0^2 \geq q^2 - q^3 - (1-q)q^2 = 0$$

where the second inequality follows from  $p_0 \leq q$ .

In summary,  $U(k=3) > U(k=0)$  and  $U(k=2) \geq U(k=1)$ . Therefore, the optimal  $k$  is either 3 or 2, depending on whether  $q \geq p_1$  or  $q < p_1$ . **Q.E.D.**

**Proof of Lemma 2:** Let  $\mathbf{b}$  be the probability each locality chooses policy  $E$  in the symmetric equilibrium. If  $\mathbf{b} \in (0,1)$ , then policies  $A$  and  $E$  must yield the same expected payoff for an incumbent, so

$$q = \mathbf{b}^2[(2q - q^2)p_1 + (1-q)^2w] + 2\mathbf{b}(1-\mathbf{b})[qp_1 + (1-q)w] + (1-\mathbf{b})^2w$$

Solving for  $\mathbf{b}$  gives

$$\mathbf{b} = \frac{1}{q} \left[ 1 - \left( \frac{p_1 - q}{p_1 - w} \right)^{1/2} \right]$$

Since  $p_1 < 1$  and  $p_0 < q$ ,  $w = \max\{qp_1, p_0\} < q$ , hence  $\mathbf{b} > 0$ . When  $\mathbf{b} < 1$ , or equivalently,

$q(2-q)p_1 > q - (1-q)^2w$ , then the symmetric equilibrium is in mixed strategies. When

$q(2-q)p_1 \leq q - (1-q)^2w$ , then all localities choose policy  $E$  with probability one. **Q.E.D.**

**Proof of Proposition 2:** When  $p_1 > q$ , under centralization, the central government chooses policy  $E$  in 2 of the 3 localities (Lemma 1). Under decentralization, the expected number of localities choosing policy  $E$  is  $3\mathbf{b}$ . Thus, centralization leads to more policy experimenting than

decentralization when  $3\mathbf{b} < 2$ . This is equivalent to  $4q(3-q)p_1 > 9q - (3-2q)^2w$ . When

$qp_1 > p_0$ , this condition is reduced to  $p_1 > 9/(21-16q+4q^2)$ . ***Q.E.D.***

**Proof of Lemma 3:** In the symmetric mixed strategy equilibrium under decentralization, policies  $A$  and  $E$  must yield the same expected payoff for an incumbent, so

$$q = \sum_{m=0}^{n-1} C_{n-1}^m \mathbf{b}^m (1-\mathbf{b})^{n-1-m} \{ [1-(1-q)^m] p_1 + (1-q)^m w \} \quad (2)$$

where  $C_{n-1}^m \mathbf{b}^m (1-\mathbf{b})^{n-1-m}$  is the probability that  $m$  out of  $n-1$  localities choose policy  $E$  when each does so with probability  $\mathbf{b}$ , and  $[1-(1-q)^m] p_1 + (1-q)^m w$  is a locality's expected payoff when  $m$  out of  $n-1$  other localities choose policy  $E$ .

As  $n \rightarrow \infty$ , by the law of large number, the number of localities choosing policy  $E$  goes to its expected value  $m^* = n\mathbf{b}$  with probability one. This implies that  $\mathbf{b} \rightarrow 0$ . Otherwise  $m^*$  goes to infinity. Consequently, the probability of discovering a successful policy goes to one, i.e.,  $(1-q)^{m^*} \rightarrow 0$ . But then every locality would like to choose  $A$  to have a reelection chance of  $p_1$ , instead of choosing  $E$  to have a reelection chance of  $q$ . We thus have a contradiction.

Since the number of localities choosing policy  $E$  goes to  $m^* = n\mathbf{b}$  with probability one, for Equation (2) to hold  $m^*$  must satisfy

$$q = [1-(1-q)^{m^*}] p_1 + (1-q)^{m^*} w$$

Solving for  $m^*$  gives

$$m^* = \frac{\ln(p_1 - q) - \ln(p_1 - w)}{\ln(1-q)}$$

Under centralization, the number of localities the central government chooses to implement policy  $E$  should be unbounded as  $n \rightarrow \infty$ . Otherwise, suppose the bound is  $K < \infty$ .

Then the probability of discovering a successful policy in the first period,  $p$ , is bounded from one. If a successful policy is discovered, the central government will win in almost every locality with probability  $p_1$ . If not, then it will win in almost every locality with probability  $p_0$ . However, if the central government implements policy  $E$  in a small fraction  $y$  of localities (hence an infinitely many as  $n \rightarrow \infty$ ), then the probability of discovering a successful policy in the first period approaches one. It will win in all  $(1-y)n$  localities with probability  $p_1$ . Clearly, by choosing a sufficiently small but positive  $y$ , the central government can be better off (sometimes strictly sometimes weakly). Therefore, the central government chooses to implement policy  $E$  in an unbounded number of localities as  $n \rightarrow \infty$ . *Q.E.D.*

**Proof of Proposition 4:** If policy  $E$  is not implemented in the first period, it will be implemented in the second period if and only if  $qp_1 \geq p_0$ . As before, let  $k$  be the number of localities that are chosen by the central government to experiment in the first period. Note that given perfect correlation, when  $k = 2$  or  $3$ , the central government will win reelection if and only if the experiment turns out to be successful (which happens with probability  $q$ ). When  $k = 1$ , it will need both non-experimenting localities to win if policy  $E$  fails, or at least one of them to win if policy  $E$  is successful. When  $k = 0$ , the central government should choose policy  $E$  in all localities if  $qp_1 \geq p_0$ , and policy  $A$  in all localities if  $qp_1 < p_0$ . In the former case, it will win reelection if and only if policy  $E$  is successful and it wins in at least two of three localities, which happens with probability  $q(3p_1^2 - 2p_1^3)$ . In the latter case, it wins reelection with probability of  $3p_0^2 - 2p_0^3$ . Therefore, the central government's expected payoff can be written as

$$U = \begin{cases} 3p_0^2 - 2p_0^3, \text{ or } q(3p_1^2 - 2p_1^3) & \text{if } k = 0; \\ q(2p_1 - p_1^2) + (1-q)p_0^2, & \text{if } k = 1; \\ q, & \text{if } k = 2, 3. \end{cases} \quad (3)$$

Under decentralization, a locality's expected payoff (i.e., probability of reelection) from experimenting in the first period is  $q$ . If choosing policy  $A$ , a locality's expected payoff is  $w = \max\{qp_1, p_0\}$  if  $j = 0$ ; and  $qp_1 + (1 - q)p_0$  if  $j = 1, 2$ ; where  $j$  is the number of other localities who choose experimenting in the first period. Note that given perfect correlation, a locality's expected payoff from choosing policy  $A$  is independent of the number of other localities that choose to experiment, as long as at least one of them experiments.

In the case of politically risky experiments ( $p_0 > q$ ), it can be easily shown that the result of Proposition 1 still holds. No locality will choose policy  $E$  under decentralization since policy  $A$  is the strictly dominant strategy for every locality. Under centralization, one can verify that  $U(k = 1) = q(2p_1 - p_1^2) + (1 - q)p_0^2 > 3p_0^2 - 2p_0^3 = U(k = 0)$  when  $p_0$  is relatively small (e.g., greater than but close to  $q$ ) and  $p_1$  is relatively large. When that is the case, the central government will choose policy  $E$  in at least one locality in the first period.

In the case of politically promising experiments ( $p_0 \leq q$ ), it can be verified that under centralization, the central government will choose policy  $E$  in at least one locality in the first period.<sup>20</sup> It will choose policy  $E$  in 2 or 3 localities in the first period if  $q \geq p_0^2 / [(1 - p_1)^2 + p_0^2]$ . Under decentralization, in the pure strategy equilibrium of the game one locality chooses policy  $E$  and the other two do not if  $q < p_0 / (1 - p_1 + p_0)$ , and all three localities chooses policy  $E$  if  $q \geq p_0 / (1 - p_1 + p_0)$ . If  $q < p_0 / (1 - p_1 + p_0)$ , there is also a symmetric mixed strategy equilibrium in which each locality chooses policy  $A$  with positive probability. In this equilibrium, with positive probability policy  $E$  is not implemented by any locality.

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<sup>20</sup> When  $qp_1 \geq p_0$ ,  $U(k = 0) = q(3p_1^2 - 2p_1^3) < q = U(k = 2, 3)$ . When  $qp_1 < p_0 < q$ , it is easy to show that  $U(k = 0) = 3p_0^2 - 2p_0^3 < q(2p_1 - p_1^2) + (1 - q)p_0^2 = U(k = 1)$ .

Note that only when  $p_0/(1-p_1+p_0) \leq q < p_0^2/[(1-p_1)^2+p_0^2]$  can the number of localities choosing policy  $E$  be higher under decentralization (i.e.,  $m^* = 3$ ) than under centralization (i.e.,  $k^* = 1$ ).<sup>21</sup> However, because of the perfect correlation, the probability of discovering a successful policy is the same under both systems. ***Q.E.D.***

## Appendix 2: Low stakes experiments

Under both centralization and decentralization, optimal second period choices are as follows. If any localities had successful experiments in the first period, then successful experiments are implemented in all localities in the second period. If no locality had a successful experiment in the first period, then those that implemented  $A$  in the first period will experiment in the second if  $qp_1 \geq p_0$  and introduce  $A$  if  $qp_1 < p_0$ . Those localities that had failed experiments in the first period will experiment again in the second period and have a chance  $q\tilde{p}$  of winning the support of a majority of local voters. (If such localities do not experiment, voters will reject the incumbent for sure.)

Under centralization, the central government's expected payoff is:

$$U = \begin{cases} 3w^2 - 2w^3, & \text{if } k = 0; \\ q(2p_1 - p_1^2) + (1-q)[w^2 + 2w(1-w)\tilde{w}], & \text{if } k = 1; \\ q^2 + 2q(1-q)(p_1 + \tilde{p} - p_1\tilde{p}) + (1-q)^2[\tilde{w}^2 + 2\tilde{w}(1-\tilde{w})w], & \text{if } k = 2; \\ 3q^2 - 2q^3 + 3q(1-q)^2(2\tilde{p} - \tilde{p}^2) + (1-q)^3(3\tilde{w}^2 - 2\tilde{w}^3), & \text{if } k = 3. \end{cases} \quad (4)$$

where  $w = \max\{qp_1, p_0\}$  and  $\tilde{w} = q\tilde{p}$ .

Under decentralization, a locality's expected payoff from experimenting in the first period is  $q + (1-q)\tilde{w}$  if  $j = 0$ ;  $q + (1-q)[q\tilde{p} + (1-q)\tilde{w}] = q + (1-q)(2-q)\tilde{w}$  if  $j = 1$ ; and  $q + (1-q)[(2q-q^2)\tilde{p} + (1-q)^2\tilde{w}] = q + (1-q)(3-3q+q^2)\tilde{w}$  if  $j = 2$ , where  $j$  is the

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<sup>21</sup> Note that  $p_0/(1-p_1+p_0) < p_0^2/[(1-p_1)^2+p_0^2]$  if and only if  $p_0 + p_1 > 1$ .

number of other localities that experiment in the first period. If choosing  $A$ , a locality's expected payoff is  $w = \max\{qp_1, p_0\}$  if  $j = 0$ ;  $qp_1 + (1-q)w$  if  $j = 1$ ; and  $(2q - q^2)p_1 + (1-q)^2w$  if  $j = 2$ .

Once again, we distinguish cases in which experimenting is “politically risky”— $q$  is low relative to  $p_0$ —from those in which experimenting is “politically promising”— $q$  is high relative to  $p_0$ . The relevant thresholds at which results under centralization and decentralization diverge are slightly different from in the high stakes case.

### *Politically risky experiments*

If  $q + (1-q)(3-3q+q^2)\tilde{w} \leq p_0$ , choosing policy  $A$  is a strictly dominant strategy for incumbents in all localities under decentralization. Hence no policy experimentation occurs under decentralization. We say that experiments are “sufficiently politically risky” when  $q \leq \mathbf{j}(p_0, \tilde{p})$ , where  $\mathbf{j}$  is the inverse function of  $f(q) = q + (1-q)(3-3q+q^2)q\tilde{p}$ .<sup>22</sup> Parallel to Proposition 1, we have:

**Proposition 6.** *Suppose  $dS \geq F$  and  $q \leq \mathbf{j}(p_0, \tilde{p})$ . Under decentralization no locality chooses policy  $E$ . Under centralization, the central government will choose policy  $E$  in at least one locality in the first period as long as  $p_0 \leq \tilde{\mathbf{r}}(p_1, \tilde{p}, q)$ , where  $\tilde{\mathbf{r}}$  is increasing in  $p_1$ .*

**Proof:** It is sufficient to show that  $U(k=1) > U(k=0)$  for relatively small  $p_0$ . Note that

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<sup>22</sup> It can be verified that  $f(q)$  is strictly increasing in  $q$ .

$$\begin{aligned}
U(k=1) - U(k=0) &= q(2p_1 - p_1^2) + 2(1-q)q\tilde{p}p_0(1-p_0) \\
&\quad - (2+q)p_0^2 + 2p_0^3 \\
&\geq q(2p_1 - p_1^2) + 2(1-q)qp_0^2(1-p_0) \\
&\quad - (2+q)p_0^2 + 2p_0^3 \\
&= q(2p_1 - p_1^2) - (2-q+q^2)p_0^2 + 2(1-q+q^2)p_0^3 \\
&> q(2p_1 - p_1^2) - (2-q+q^2)p_0^2
\end{aligned}$$

Hence, as long as  $q(2p_1 - p_1^2) > (2-q+q^2)p_0^2$ , then  $U(k=0) < U(k=1)$ . Clearly the larger  $p_1$ , the more likely that  $U(k=0) < U(k=1)$ . Also note that this condition is compatible with that  $q + (1-q)(3-3q+q^2)\tilde{w} \leq p_0$  for a non-degenerate set of parameter values (e.g., relatively large  $p_1$  and small  $q$  and  $\tilde{p}$ ). ***Q.E.D.***

Proposition 6 shows that centralization promotes more experimentation than decentralization when policy experiments are low stakes but politically risky. Like Proposition 1, the free riding problem under decentralization and the risk-taking effect under centralization are the reasons behind Proposition 6.

#### *Politically promising experiments*

If experiments are low stakes and sufficiently politically promising,  $q > p_0/p_1$ , we can prove results similar to Lemmas 1 and 2 and obtain the following proposition.

**Proposition 7.** *Suppose  $dS \geq F$  and  $q > p_0/p_1$ . Compared with the expected number of localities choosing policy E in the symmetric decentralization equilibrium, centralization leads to more policy experimentation when  $p_1 \geq (1-q)\tilde{p} + 9/[9 + 4(1-q)(3-q)]$ .*

**Proof:** First consider centralization. When  $p_0 < qp_1$  and hence  $w = qp_1$ , clearly

$U(k=3) > U(k=0)$ . After some algebraic calculation, we have  $U(k=2) - U(k=1)$  equal to

$$\begin{aligned} & q^2(1-p_1)^2 + p_1w(1-q)^2 + (1-q)\tilde{w}[2(1-p_1)(1-qw) + (1-q)(1-2w)\tilde{w}] \\ & = q^2(1-p_1)^2 + 2(1-q)\tilde{w}(1-p_1)(1-qw) + p_1w(1-q)^2[1+q(1-2w)(\tilde{p}/p_1)^2] \end{aligned}$$

If  $w \leq 0.5$ , then clearly the above expression is positive. If  $w > 0.5$ , note that

$$1 + q(1-2w)(\tilde{p}/p_1)^2 \geq 1 + q(1-2w) \geq 1 - q$$

hence  $U(k=2) > U(k=1)$ . Thus, the central government's optimal  $k$  is at least 2.

Now consider decentralization. Let  $\mathbf{b}$  be the probability each locality chooses policy  $E$  in the symmetric equilibrium. If  $\mathbf{b} \in (0,1)$ , then policies  $A$  and  $E$  must yield the same expected payoff for an incumbent. It can be checked that

$$\mathbf{b} = \frac{1}{q} - \frac{1}{q} \left[ \frac{p_1 - (1-q)\tilde{p} - q}{(1-q)(p_1 - (1-q)\tilde{p})} \right]^{\frac{1}{2}}$$

Clearly  $\mathbf{b} > 0$ . When  $p_1 > (1-q)\tilde{p} + 1/(3-3q+q^2)$ , then  $\mathbf{b} < 1$ ; otherwise, then all localities choose policy  $E$  with probability one.

Centralization leads to more policy experimentation than decentralization when  $3\mathbf{b} \leq 2$ , which is equivalent to  $p_1 \geq (1-q)\tilde{p} + 9/[9+4(1-q)(3-q)]$ . ***Q.E.D.***

Similar to Proposition 2, in the case of politically promising low stakes experiments, centralization can lead to more policy experimentation than decentralization under plausible conditions when  $p_1$  is relatively high. On the other hand, due to the risk-conserving effect under centralization, decentralization can promote more experimentation than centralization under certain conditions when  $p_1$  is relatively low. The main insights of our model hold whether policy experiments are high stakes or low stakes.