Samuelson Meets Federalism: Local Production of a National Public Good

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This paper studies an overlooked phenomenon in the provision of public goods: local production of a national public good, such as the manufacture of fighter planes (which contribute to national defense) in many different jurisdictions across the country. Because local production of the national good raises local incomes, each jurisdiction seeks to raise its share of the good's production. A subset of jurisdictions then forms a minimum winning coalition, which offers equal production shares to its members and smaller (possibly zero shares) to non-members, while choosing the provision level of the national good. The outcome is inefficient, with production inefficiently concentrated and the public good also overprovided (because income benefits reducing the good's perceived marginal cost). Empirical results confirm the prediction that the location of production is important in determining Congressional support for federal program spending.

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1. Introduction

A cartoon in Harvey Rosen's public finance textbook (Rosen, 1987, p. 96), shows an Air Force general pointing to a diagram of a jet fighter and saying: "At last! A weapons system absolutely impervious to attack: It has components manufactured in all 435 congressional districts!" At first, one might think this statement is about "pork-barrel" politics, where taxes raised at the national level support local spending that only benefits individual jurisdictions. But since defense spending is valued by the entire country, the general is not making a pork-barrel statement at all, but is instead talking about something different: *local production of a national public good.* His point is that local production of defense components builds overall support for national defense by raising local incomes, which in turns makes widespread distribution of production desirable from the Pentagon's point of view.[1]

Despite much attention to pork-barrel spending, a treatment of local production of national public goods in a federalist system is entirely absent from the literature. The present paper provides a theoretical analysis of this phenomenon along with empirical evidence. The key feature of the model is that the level of the national public good equals the sum of the levels produced in the various jurisdictions. This assumption is roughly accurate for production of fighter planes, and it is perhaps even more accurate for research grants. The model also makes explicit how public production generates local income. Taking this income effect into account, the analysis then portrays the political struggle in the national legislature over the assignment of production to jurisdictions, which is resolved by imposition of the wishes of a "minimum winning coalition." In the model, this coalition assigns each of its member jurisdictions a larger production share than the shares given to nonmembers (which may be zero), and it also sets the level of the national public good (which, together with the production share, determines a jurisdiction's output).

The analysis generates two notable efficiency verdicts: production of the national public good is inefficiently concentrated instead of equally (and optimally) divided across jurisdictions; and the level of the good is inefficiently high relative to the optimal level, which arises with equal production shares. These results are entirely new to the literature.[2]

It is important to note the exact way in which federalism plays a role in our analysis. Public goods that are purely local are absent from the model, which means that this aspect of federalism is missing, along with a connection to the huge Tiebout literature. Rather, for our analysis, federalism's crucial feature is the existence of many subnational jurisdictions with voting power in a national legislature, which controls the provision of a national public good. This local voting power, combined with potentially unequal allocation of the public good's production across jurisdictions, creates the issues on which the paper focuses.

While our model has no exact precedent in the prior literature, it has most in common with the frameworks of Weingast, Shepsle and Johnson (1981) and Shepsle and Weingast (1981), which attempt to explain pork barrel spending. An important distinction between our work and these papers is that consumption (pork-barrel) benefits from federal spending in a jurisdiction are entirely local, in contrast to the present framework. The pork-barrel models also include a local income benefit, but without the detailed micro-foundations included here. Other papers further explore the local benefits from federal spending, with Knight (2004) developing an empirically oriented model of highway spending, while Knight (2002) portrays localities as relying partly on locally generated revenue for highway spending (which is locally beneficial) in addition to federal grants (see also Knight, 2008).[3]

The local pork-barrel spending portrayed in these papers is inefficiently high because each of the n jurisdictions pays only $1/n$ of the costs while receiving all the benefits. By contrast, overprovision arises in our model because the local income benefits from concentrated production reduce the perceived marginal cost of the public good. Thus, the two models have very different sources of inefficiency.

Developing an empirical test of our theory requires noting that the predictions of the model do not exactly match the situation described by the Air Force general, given that concentration of production in the winning coalition may mean its absence from some jurisdictions. But the

general's view is more broadly correct in that increasing the production share of the median jurisdiction will tend to raise the chosen level of the public good. Therefore, we expect an inverse relationship between total spending on the good and the extent of concentration of production.

To test this prediction, we develop an empirical test using the Consolidated Federal Funds Report (CFFR) data. The CFFR data reports where federal funds are spent in the US. The data covers grants to institutions (either public or private) under a large number of federal programs, which cover a wide variety of purposes. Almost 500 separate programs are present in the first year of the dataset (1983), and over 1,200 are present by the last year (2010). The data cover not only state-level spending but also spending at the county level within each state. Our measure of spending concentration is the Herfindahl-Hirschman index (HHI), and our test asks whether lower concentration of spending (a lower HHI) is consistent greater program grant spending.

We use use two separate HHI variables, as suggested by the structure of the US Congress. The first is a Herfindahl index based on state spending shares, which is predicted to affect political support within the US Senate. In addition, we create a within-state HHI based on the program's county-level spending shares, which may affect political support within the House of Representatives. The results show that both of the HHI measures are inversely related to overall program spending, showing as predicted that lower spending concentration generates more program spending. This finding holds for a number of alternative samples that vary according to whether grant funds are distributed widely or narrowly, and whether programs are new or have existed for an extended period of time.

The plan of the paper is as follows. To explain the model structure in a simple fashion, section 2 considers the case of an economy with a single jurisdiction. Section 3 repeats this basic analysis for two-jurisdictions, where production of the national public good is divided between them. Section 4 shows for the two-jurisdiction case how consumption of the private good and the preferred level of the national public good depend on a jurisdictions production share for the public good. These findings are generalized to an n-jurisdiction economy. Using the results of section 4, section 5 analyzes voting on production shares and on the level of the national

public good, characterizing the equilibrium and deriving the efficiency results described above. Section 6 considers extensions to the model, and Section 7 presents the empirical work. Section 8 offers a summary and conclusions.

2. The single-jurisdiction case

To understand how a model works in which public-good production generates income, it is helpful to first consider an economy with just a single jurisdiction. The multiple-jurisdiction case, which is the main focus of the analysis, is considered subsequently. Consider the simplest setup, where the jurisdiction has a fixed amount of homogeneous labor $\overline{L}$ that is divided between production of a numeraire private good x and the public good z (in amounts L_x and L_z), with no other inputs required. The possibility of different labor types, suited to production of the different goods, is thus suppressed. Outputs of x and z are given by the well-behaved production functions $f(L_x)$ and $g(L_z)$. The labor market equilibrium is found conditional on the level of z, which is then chosen through a voting process.

Private producers maximize profit, which equals $f(L_x) - wL_x$, by choice of L_x, where w is the wage. The first-order condition is

$$f'(L_x) \quad = \quad w. \tag{1}$$

For a given z, L_z must satisfy $g(L_z) = z$, which determines L_z as a function of z, written as $L_z(z)$. The labor available for x production is then equal to $L_x(z) = \overline{L} - L_z(z)$, and the wage that clears the labor market is

$$w(z) \quad \equiv \quad f'(\overline{L} - L_z(z)). \tag{2}$$

Differentiation of $g(L_z) = z$ shows that $L_z' = 1/g' > 0$ and $L_z'' = -(1/g'^2)g''L_z' > 0$, noting $g'' < 0$. In addition, differentiating (2) yields $w' = -f''L_z' > 0$, noting $f'' < 0$. The wage rises because additional public production absorbs labor and thus tightens the private labor market, where the wage is determined. The wage's second derivative equals $w'' = f'''(L_z')^2 - f''L_z''$. Although w'' is ambiguous in sign because of the indeterminancy of the sign of f''', the analysis

assumes $w'' > 0$, an inequality that is crucial in subsequent results. A sufficient condition for this outcome is $f''' \geq 0$, which includes the cases where f is a power function (L_x^τ, with $\tau < 1$) or quadratic ($f''' = 0$).

The private producer earns a profit of $\pi(z) = f(L_x(z)) - w(z)L_x(z)$, and differentiation yields

$$\pi' \;=\; (f' - w)L_x' \;-\; w'L_x \;=\; -w'L_x \;<\; 0. \tag{3}$$

using (1), so that profit is decreasing in z. Summing up, the central functions used in the analysis satisfy

$$\pi'(z),\ L_x'(z) < 0, \quad L_z'(z),\ L_z''(z),\ w'(z),\ w''(z) > 0, \tag{4}$$

with the last inequality holding by assumption.

Income $I(z)$ and the tax liability $T(z)$ for an individual consumer are

$$I(z) \;=\; w(z) \;+\; \pi(z)/\overline{L}, \qquad T(z) \;=\; w(z)L_z(z)/\overline{L}, \tag{5}$$

with $\pi/\overline{L}$ giving the worker's share of profit and $w(z)L_z(z)$ giving the cost of producing z, which is divided among the population. Since $w', L_z' > 0$, T is obviously increasing in z. Differentiating, $I(z)$ in (5) using (4), income also increases with z:

$$I' \;=\; w' \;+\; \frac{\pi'}{\overline{L}} \;=\; \frac{w'\overline{L} \;-\; w'L_x}{\overline{L}} \;=\; \frac{w'L_z}{\overline{L}} \;>\; 0. \tag{6}$$

In (6), the decline in profit when z increases (from (3)) tends to offset the z-induced increase in the wage, but since the offset is incomplete, income rises with z, a crucial conclusion.

From the individual budget constraint, x consumption is given by $x(z) = I(z) - T(z)$. The utility function, which depends on x and z, is common to all individuals, and it is written $u(x(z), z)$. Substituting for $x(z)$, the first-order condition that determines the preferred z is $u_z/u_x = -x'(z) = I'(z) - T'(z)$. Using (6) and differentiating $T(z)$ in (5),

$$x' \;=\; \frac{w'L_z}{\overline{L}} \;-\; \frac{(w'L_z + wL_z')}{\overline{L}} \;=\; -\frac{wL_z'}{\overline{L}}. \tag{7}$$

Setting (7) equal to u_z/u_x and multiplying through by $\overline{L}$, the first-order condition for choice of z becomes

$$\overline{L}\frac{u_z}{u_x} \quad = \quad wL_z'. \tag{8}$$

The LHS of (9) is the sum of the marginal rates of substitution, while the RHS is the usual marginal cost of z in per capita terms, equal to the wage times the additional labor input required when z rises (L_z'). Thus, (8) is the familiar Samuelson condition for provision of a public good. It is important to note that the positive effect of z on income does not appear in (8). The reason is that it is exactly offset in (7) by the cost component $w'L_z/\overline{L}$, which captures the effect of the higher wage on the cost of z, holding L_z fixed.

The conclusion, therefore, is that even though public production generates income, this income effect does not influence the choice of z. As will be seen below, this independence disappears in an economy with multiple jurisdictions when production of the public good is unequally allocated across them.

3. The case of two jurisdictions

Consider now the case where production of a national public good is divided between two jurisdictions. The public-good level z is the sum of the levels produced locally, with $z = z_1 + z_2$ holding in a world with two jurisdictions. For simplicity, suppose that whatever the value of z, constant shares are produced within the individual jurisdictions, with $z_1 = \alpha_1 z$ and $z_2 = \alpha_2 z = (1 - \alpha_1)z$. The public-good production function $g(\cdot)$ is common to both jurisdictions, ruling out location-specific production advantages (which are briefly considered in section 6 below). This assumption implies, for example, that both jurisdictions are equally adept at carrying out cancer research.

The national government, which carries out the z-production in each of the jurisdictions, adds up its costs and then covers them via equal head taxes on each consumer. Therefore, each resident of jurisdiction 1 or 2 pays a tax of

$$T(z, \alpha_1) \quad = \quad \frac{w(\alpha_1 z)L_z(\alpha_1 z) \ + \ w((1-\alpha_1)z)L_z((1-\alpha_1)z)}{2\overline{L}}, \tag{9}$$

where $2\overline{L}$ gives the national population. Note that the previous $w(\cdot)$ and $L_z(\cdot)$ functions in (9) are evaluated at the jurisdictional z production levels, equal to $\alpha_1 z$ and $(1-\alpha_1)z$.

In addition, suppose that profits from each jurisdiction are equally distributed to all residents in the economy. Therefore, income for a resident of jurisdiction 1 equals

$$I_1(z,\alpha_1) \quad = \quad w(\alpha_1 z) \ + \ \frac{\pi(\alpha_1 z) + \pi((1-\alpha_1)z)}{2\overline{L}}, \tag{10}$$

where the numerator of the ratio term is total profit. Using (1), the derivative of I_1 with respect to z equals

$$\frac{\partial I_1(z,\alpha_1)}{\partial z} \quad = \quad \alpha_1 w_1' \ - \ \frac{\alpha_1 w_1' L_{x1} + (1-\alpha_1) w_2' L_{x2}}{2\overline{L}}, \tag{11}$$

using the shorthand $w_1 = w(\alpha_1 z)$, $w_2 = w((1-\alpha_1)z)$, etc. If (11) is evaluated under symmetric production shares, with $\alpha_1 = \alpha_2 = \hat{\alpha} = 1/2$, it equals

$$\frac{\hat{\alpha} w'(\hat{\alpha} z) L_z(\hat{\alpha} z)}{\overline{L}}. \tag{12}$$

Except for the $\hat{\alpha}$ factor, the expression in (12) is the same as the income-change expression in the single-jurisdiction case, $w' L_z/\overline{L}$.

The z-derivative of the tax expression in (9) is

$$\frac{\partial T(z,\alpha_1)}{\partial z} \quad = \quad \frac{\alpha_1 w_1' L_{z1} + \alpha_1 w_1 L_{z1}' + (1-\alpha_1) w_2' L_{z2} + (1-\alpha_1) w_2 L_{z2}'}{2\overline{L}}, \tag{13}$$

Again evaluating under symmetry, (13) reduces to

$$\frac{\hat{\alpha}[w'(\hat{\alpha} z) L_z(\hat{\alpha} z) + w(\hat{\alpha} z) L_z'(\hat{\alpha} z)]}{\overline{L}}. \tag{14}$$

With private-good consumption equal to $x_1 = I_1 - T$, the effect of z on x_1 (using (12) and (14)) is given by

$$\frac{\partial x(z,\alpha_1)}{\partial z}|_{\alpha_1=\hat{\alpha}} \quad = \quad \left(\frac{\partial I_1(z,\alpha_1)}{\partial z} \ - \ \frac{\partial T(z,\alpha_1)}{\partial z}\right)|_{\alpha_1=\hat{\alpha}} \quad = \quad - \ \frac{\hat{\alpha} w(\hat{\alpha} z) L_z'(\hat{\alpha} z)}{\overline{L}}, \tag{15}$$

evaluating at symmetric production shares. Setting (15) equal to u_z/u_x, and multiplying through by $\overline{L}/\hat{\alpha} = n\overline{L}$, the first-order condition determining jurisdiction 1's preferred z is then

$$2\overline{L}\frac{u_z}{u_x} = wL'_z, \tag{16}$$

which is the Samuelson condition for the two-jurisdiction economy (with equal shares, the same condition will apply to jurisdiction 2).

As in the single-jurisdiction case, the RHS of (16) is the usual expression for the marginal cost of the public good, with the income effect of extra z not captured. When $\alpha_1 \neq 1/2$, however, the RHS of the first-order condition contains income effects. The RHS contains a generalized marginal-cost expression, equal to $\alpha_1 w_1 L'_{z1} + (1-\alpha_1)w_2 L'_{z2}$ (higher costs in both jurisdictions are captured). It also contains the term $-\overline{L}(\alpha_1 w'_1 - (1-\alpha_1)w'_2)$, which captures income effects and is negative (positive) when $\alpha_1 > (<)\ 1/2$, given $w'' > 0$. Thus, u_z/u_x in jurisdiction 1 is set equal to a term that is less than marginal cost when its production share exceeds 1/2, and conversely when $\alpha_1 < 1/2$. This behavior of the first-order condition when production shares are unequal plays a crucial role below.

4. The consumption effects of changes in the production share

4.1. The share's effect on x consumption

Movement away from equal production shares will affect a jurisdiction's x consumption, holding z fixed, while also altering its preferred z. Regarding the effect on x, the first observation is, that for any z, jurisdiction 1's x consumption is larger than jurisdiction 2's when $\alpha_1 > 1/2$. This conclusion, which implies that consumer utility is higher in jurisdiction 1, follows because the wage component of income in (10) is then larger in jurisdiction 1 than in jurisdiction 2, while income's profit component from (10) along with the tax paid from (9) are the same in both jurisdictions. It can also be shown that, since $\alpha_1 > 1/2$ means lower x production in jurisdiction 1 than in 2, jurisdiction 1 consumes more x than it produces while the reverse relationship holds in jurisdiction 2.[4]

Although the x comparison between the jurisdictions is useful, subsequent results require further information regarding the exact shape of the relationship between x_1 and the production

share α_1. Accordingly, consider the effect on $x_1 \equiv x(z, \alpha_1)$ of an increase in α_1. To start, the income expression in (10) is differentiated with respect to α_1, yielding

$$\frac{\partial I_1}{\partial \alpha_1} \;=\; zw_1' \;-\; \frac{zw_1' L_{x1} - zw_2' L_{x2}}{2\overline{L}} \;=\; \frac{z}{2\overline{L}}[w_1'(2\overline{L} - L_{x1}) \;+\; w_2' L_{x2}] \;>\; 0, \tag{17}$$

so that jurisdiction 1's income rises with its production share. The α_1-derivative of the tax expression in (10) is

$$\frac{\partial T}{\partial \alpha_1} \;=\; \frac{zw_1' L_{z1} + zw_1 L_{z1}'}{2\overline{L}} \;-\; \frac{zw_2' L_{z2} + zw_2 L_{z2}'}{2\overline{L}} \tag{18}$$

Letting q denote an arbitrary public-good production level, it is easily seen that $w'(q)L_z(q) + w(q)L_z'(q)$ is increasing in q given $w'', L_z'' > 0$. It follows that (19) is positive for $\alpha_1 > 1/2$, in which case the q argument of the terms in the first ratio ($\alpha_1 z$) is larger than the q argument of the terms in the second ratio ($(1 - \alpha_1)z$). Similarly (18) is negative for $\alpha_1 < 1/2$ and equal to zero for $\alpha_1 = 1/2$. As a result, $\partial x_1/\partial \alpha_1$, which equals (17) minus (18), is positive when $\alpha_1 \leq 1/2$. By continuity, $\partial x_1/\partial \alpha_1$ is also guaranteed to be positive for an α_1-range above 1/2. The derivative could be positive all the way up to $\alpha_1 = 1$, but negative values beyond $\alpha_1 = 1/2$ cannot be ruled out. Summarizing yields

> **Proposition 1.** *In the two-jurisdiction case, x consumption in jurisdiction 1 is increasing in its production share α_1 for $0 \leq \alpha_1 \leq 1/2$ and for a range above 1/2.*

It is important to note that the positive effect of a higher production share on income from (17) is a driving force behind this conclusion, especially in the range just above $\alpha_1 = 1/2$, where the tax effect works in the opposite direction. Subsequent results, which rely on Proposition 1, are thus closely tied to the role of public production in raising local incomes.

Note that positivity of $\partial x_1/\partial \alpha_1$ at $\alpha_1 = 1/2$ is consistent with the previous conclusion that x is larger in jurisdiction 1 than in jurisdiction 2 when $\alpha_1 > 1/2$. If this derivative were instead negative, the latter conclusion on x would be violated at α_1 values immediately above 1/2. The derivative could eventually become negative, however, without necessarily leading to such a violation.

4.2. The share's effect on the preferred z

Consider now the effect of jurisdiction 1's production share on its preferred level of z. Recall that the first-order condition in (16), which corresponds to the usual Samuelson condition, was derived under the assumption of equal production shares, where $\alpha_1 = \hat{\alpha} = 1/2$. The goal is to find how the preferred z changes relative to this Samuelson level as α_1 diverges from 1/2. The approach is to differentiate (16) with respect to α_1 and then deduce the direction of α_1's effect on the preferred z, with the derivative evaluated under equal production shares. To carry out this task, it is helpful to rewrite (16) as

$$\left[MRS(x(z,\alpha_1),z) \;+\; \frac{\partial x(z,\alpha_1)}{\partial z}\right]|_{\alpha_1=\hat{\alpha}} \;=\; 0, \tag{19}$$

where $MRS \equiv u_z/u_x$, which depends on the x and z arguments of the utility function. The sign of the α_1-derivative of (19) yields the direction of the effect on z.

The α_1-derivative of the MRS term in (19) is $\partial MRS/\partial x$ times $\partial x/\partial\alpha_1$. When evaluated at $\alpha_1 = 1/2$, $\partial x/\partial\alpha_1$ is positive from Proposition 3. Since $\partial MRS/\partial x > 0$ holds when z is a normal good, the derivative of the MRS term in (19) is then positive, when evaluated at equal production shares.

The α_1-derivative of $\partial x/\partial z$ from (20), or $(\partial^2 x(z,\alpha_1)/\partial z\partial\alpha_1)|_{\alpha_1=\hat{\alpha}}$, is the difference between the α_1 derivatives of (11) and (13). It is easy to see that the derivative of $\partial T/\partial z$ in (13) with respect to α_1 is zero when evaluated under equal shares ($\alpha_1 = \hat{\alpha}$), a consequence of the offsetting changes in α_1 and $1-\alpha_1$. Therefore, the α_1-derivative of $\partial I_1/\partial z$ in (11) determines the sign of the desired derivative. Once again, the α_1-derivative of the ratio term in (11) is zero under equal shares because of the offsetting changes in α_1 and $1-\alpha_1$. Thus, only the first term in (11) ($\alpha_1 w_1'$) contributes to the derivative, so that

$$\frac{\partial^2 x(z,\alpha_1)}{\partial z\partial\alpha_1}|_{\alpha_1=\hat{\alpha}} \;=\; \frac{\partial^2 I_1}{\partial z\partial\alpha_1}|_{\alpha_1=\hat{\alpha}} \;=\; w_1'(\hat{\alpha}z) \;+\; \hat{\alpha}z w_1''(\hat{\alpha}z) \;>\; 0. \tag{20}$$

Combined with the earlier conclusion that $\partial MRS/\partial\alpha_1$ is positive, the upshot is that the α_1-derivative of the entire expression in (19) is positive. With (19) then increasing in α_1, and with

the z-derivative of (19) negative by the second-order condition (assumed to hold), an offsetting increase in z is required to make (19) again equal to zero following an increase in α_1. The following conclusion can then be stated:

Proposition 2. *Jurisdiction 1's preferred level of z is increasing in its public-good production share α_1 when α_1 lies in a neighborhood of* $1/2$.

The intuition for this result is as follows. First, normality of z means that the higher x caused by a higher production share raises the marginal benefit of the public good (the MRS), which tends to increase the desired level of z. Second, a higher production share reduces the marginal cost of z in terms of forgone x, given by $-\partial x/\partial z$ ($-\partial^2 x/\partial z \partial \alpha_1$ is negative by (20)). With marginal benefit higher and marginal cost lower, the preferred z rises. It is important to note that the production share's beneficial effect on marginal cost arises through the income channel. In particular, a higher α_1 increases the size of z's favorable effect on local income, given by $\partial I_1/\partial z$ from (11). Note that if preferences were quasi-linear, making the MRS a constant, the effect of α_1 on the preferred z would operate entirely through this income channel.

4.3. Generalization to more than two jurisdictions

This analysis can be generalized easily to a setting with $n > 2$ jurisdictions. Suppose that m of these jurisdictions (including jurisdiction 1) each have a production share of α_1 and that the remaining $n - m$ each have a production share of α_2. Individual income in jurisdiction 1 is then

$$I_1 \;=\; w(\alpha_1 z) \;+\; \frac{m\pi(\alpha_1 z) + (n-m)\pi(\alpha_2 z)}{n\overline{L}}, \tag{21}$$

while the tax payment is

$$T \;=\; \frac{mw(\alpha_1 z)L_z(\alpha_1 z) \;+\; (n-m)w(\alpha_2 z)L_z(\alpha_2 z)}{n\overline{L}}. \tag{22}$$

Computing z-derivative of $x_1 = I_1 - T$ using (21) and (22) and evaluating under equal shares yields the previous first-order condition (16), where 2 is replaced by n.

While $\partial\alpha_2/\partial\alpha_1$ equalled -1 in the 2-jurisdiction case, the derivative is now computed by differentiating the condition $m\alpha_1 + (n-m)\alpha_2 = 1$, which says that the production shares add up to 1. As a result $\alpha_2 = (1-m\alpha_1)/(n-m)$ and $\partial\alpha_2/\partial\alpha_1 = -m/(n-m)$. Using this $\partial\alpha_2/\partial\alpha_1$ derivative and repeating the previous analysis then yields analogs to Propositions 1 and 2:

Proposition 3. *Suppose the economy contains $n > 2$ jurisdictions divided into groups of sizes m and $n-m$, with jurisdictions in each group having a common production share and the m-group share denoted α_1. Then*

(*a*) *the m-group's x consumption is increasing in its production share α_1 for $0 \le \alpha_1 \le 1/n$ and for a range above $1/n$.*

(*b*) *the m-group's preferred z level is increasing in α_1 when α_1 lies in a neighborhood of $1/n$.*

5. Voting on production shares and the level of the public good

5.1. Voting on production shares

To characterize voting on production shares, assume that each jurisdiction chooses a single representative to the national legislature, who takes into account the income benefit from local z production. Legislators form coalitions[5] and vote over production-share proposals, which specify the shares of each jurisdiction, conditional on the level of z. Share proposals are constrained to specify a uniform individual share of α_1 for jurisdictions within the coalition, as well as a uniform share of α_2 for jurisdictions outside the coalition. With the number of jurisdictions n assumed to be odd, the size of the minimum winning coalition equals $k = (n+1)/2$. An equilibrium coalition must then have a size m satisfying $m \ge k$.[6]

The winning coalition's choice of production shares is conditional on the level of z, with the coalition able to impose its preferred z once shares are set. This process can be viewed as a simultaneous choice of α_1 and z by the winning coalition, but where the choice is decomposed into two stages, with α_1 chosen conditional on z and z then chosen in a first stage, taking account of its effect on the optimal α_1. Specifically, viewing z as fixed and letting x_1 denote the x consumption of coalition members, the winning coalition maximizes $u(x_1(z,\alpha_1), z)$ by choosing α_1, with the goal of maximizing x_1. This choice yields an optimal value $\alpha_1(z)$ that depends on z. Then in the first stage, z is chosen taking account of its effect on α_1, making use

of the envelope theorem. The following analysis focuses on the choice of α_1, with the first-stage choice of z considered in section 5.2 below.[7]

From Proposition 3a, the x consumption of coalition members (x_1) initially increases as their common production share α_1 rises above $1/n$. Therefore, a group of k jurisdictions can make its members better off by forming a winning coalition that sets the common member share α_1 marginally above $1/n$ while setting α_2, the common nonmember share, marginally below $1/n$.

However, the coalition members may benefit from further increases in α_1 beyond this initial marginal change, with appropriate adjustment of α_2. The details depend on the behavior of x_1 as the production share α_1 increases. Letting x_1^* denote the maximum value of x_1, two cases can be distinguished. In the first case, the range above $1/n$ over which x_1 is increasing extends beyond $1/k$, so that x_1^* corresponds to an $\alpha_1 = \alpha^* \geq 1/k$. In this case, the coalition will set its size m at k, the smallest possible value, and will set $\alpha_1 = 1/k$ and $\alpha_2 = 0$. Note that, while a smaller coalition of size $m = 1/\alpha^* < k$ would yield the even more favorable α_1 value of α^*, this coalition does not have a winning size.

In the second case, x_1 starts to decrease before α_1 reaches $1/k$, so that the maximal x_1^* value is achieved at a smaller production share, denoted $\widehat{\alpha}_1$. The equilibrium coalition then has size k, sets $\alpha_1 = \widehat{\alpha}_1$, where $1/n < \widehat{\alpha}_1 < 1/k$, and sets α_2 at the value satisfying $k\widehat{\alpha}_1 + (n-k)\alpha_2 = 1$. This value that is greater than zero (because $\widehat{\alpha}_1 < 1/k$) but less than $1/n$. Summarizing yields

> **Proposition 4.** *The equilibrium coalition has size k and sets the common production share α_1 for its members above $1/n$, with α_2 set below $1/n$. If x_1 is maximized at an α_1 value above $1/k$, then the coalition sets $\alpha_1 = 1/k$ and $\alpha_2 = 0$, while $\alpha_1 < 1/k$ and $\alpha_2 > 0$ hold otherwise.*

The resulting concentration of z production in the equilibrium coalition is due to Proposition 3a, which says that a jurisdiction's x consumption rises with its production share as a result of the share's positive impact on income.

This result could be viewed as incomplete because it does not identify exactly which k jurisdictions constitute the winning coalition. Shepsle and Weingast (1981) explore this issue in a pork-barrel setting, arguing that the prospect of being left out of the winning coalition

may lead jurisdictions to agree on a "universalism" rule, in which every jurisdiction (rather than just coalition members) receives pork barrel spending. Universalism in the present case would simply amount to setting $k = n$.

5.2. Taking account of harm to nonmembers

Harm to nonmembers of the coalition can motivate an alternative view of coalition's choice of α_1. As the nonmembers' common production share falls below $1/n$, the resulting harm creates political ill-will that may make cooperation among legislators on other matters more difficult. Suppose that the resulting political cost is tolerable to coalition members as long as the gap between production shares inside and outside the coalition is less than $\lambda > 0$, but is unacceptable when gap is greater than λ ($\lambda < 1/n$ must hold). The coalition will then never wish to set a production share α_1 so high that the gap between the shares exceeds λ. With a coalition size of m, the α_1 value where the gap equals λ, denoted by $\overline{\alpha}$, is determined by the condition $m\overline{\alpha} + (n - m)(\overline{\alpha} - \lambda) = 1$. Solving for $\overline{\alpha}$ yields

$$\overline{\alpha}(m) \quad = \quad \frac{1}{n} \, + \, \frac{n-m}{n}\lambda, \tag{23}$$

so that $\overline{\alpha}$, which depends on m, equals $1/n$ plus a fraction of the maximal gap λ.

If λ is sufficiently small, then difference between $\overline{\alpha}$ and $1/n$ from (23) is small enough that the coalition's x_1 value is guaranteed to increase with α_1 over the interval $[1/n, \overline{\alpha}]$, by Proposition 3a. As a result, the coalition will set $\alpha_1 = \overline{\alpha}(m)$, leading to the maximal gap λ between member and nonmember shares. This analysis, however, is conditional on the coalition size m, which is then adjusted to further increase the coalition's common production share. As can be seen from (23), $\overline{\alpha}(m)$ is decreasing in m, which means that m should be set as small as possible, equal to the size k of the smallest winning coalition.[8] Note that $\alpha_2 = \overline{\alpha}(k) - \lambda = 1/n - (k/n)\lambda$.

5.3. Voting on the level of the public good and efficiency

Having imposed production shares to maximize x_1 conditional on z, the winning coalition then sets its preferred z level by maximizing $u(x(z, \alpha_1(z)), z)$, where $\alpha_1(z)$ is again the coalition's preferred α_1 conditional on z. As usual in a two-stage depiction of a simultaneous

optimization problem, the effect of z on α_1 vanishes, so that the first-order condition for choice of z is given by (19) with $\hat{\alpha}$ replaced by $\alpha_1(z)$.[9]

Proposition 3b, which is based on the generalization of the first-order condition in (19), can be used to draw an important conclusion about the winning coalition's preferred z level. Assuming that the coalition's optimal α_1 is sufficiently close to $1/n$ (as would occur, for example, when λ is small in the political-cost version of the model), then Proposition 3b, which applies in the neighborhood of equal production shares, can be used. Since the coalition's common production share exceeds $1/n$, Proposition 3b implies that the coalition's preferred z-level is larger than the value that would emerge with equal production shares. Summarizing yields

Proposition 5. *If α_1 is close enough to $1/n$ to invoke Proposition 3b, then the chosen public-good level, which is the common preferred level of the members of the equilibrium coalition, is larger than the level that would be chosen if production shares were equal for all jurisdictions, a level that satisfies the Samuelson condition.*

Note that Proposition 5 also implies that, among jurisdictions outside the winning coalition (whose share α_2 is less than but close to $1/n$), the common preferred z value is less than the equal-shares z and thus less than the coalition's preferred z.

The next step is to evaluate the efficiency of this equilibrium outcome. As shown in section 1 of the appendix, efficiency requires satisfaction of the Samuelson condition ((16) with 2 replaced by n) and an equal division of z production across jurisdictions. This second requirement is natural given that, with decreasing returns ($g'' < 0$), unequal production would lead to higher costs. The following conclusion is then immediate:

Proposition 6. *The equilibrium of Proposition 5 is inefficient, with production of z inefficiently concentrated in the equilibrium coalition's jurisdictions, and the level of z inefficiently high.*

Thus, the beneficial effect of z production on local incomes leads to an equilibrium coalition that concentrates production, and this concentration in turn raises the preferred z-level among coalition jurisdictions, leading to excessive provision of the public good.

In contrast to the pork-barrel model, an efficient level of z would emerge in the present setting if symmetry were imposed exogenously, with production shares constrained to be equal. The reason is that with equal shares, each consumer pays an equal per capita portion $(1/n\overline{L})$ of z's national cost, which is the sum of identical costs incurred in symmetric jurisdictions. This situation, where identically situated consumers vote on the level of a pure public good while equally sharing its cost, is well known to lead to an efficient choice. The source of inefficiency in the present model is thus concentration of production under the winning coalition, which reduces the members' perceived marginal cost of z (as explained above), encouraging excessive provision. In the pork-barrel model, by contrast, overprovision arises because individual jurisdictions reap all the benefits of local spending while paying only their share of the cost.

5.4. Numerical example

It is useful to illustrate an equilibrium using a numerical example. Suppose that the production functions for z and the private good are identical and given by $L^{0.8}$, where L is either L_z or L_x, and that the utility function is Cobb-Douglas, given by $x^{1-\theta}z^{\theta}$, with $\theta = 0.1$. Suppose in addition that $n = 15$ and that m is equal to the size k of the minimum winning coalition, in this case 8, while $\overline{L} = 2$. Under these assumptions, x_1 is increasing in α_1 when $\alpha_1 = 1/n = 0.067$, as predicted by Proposition 3a. It reaches a maximum at $\alpha_1 = 0.106$, with the x_1-maximizing value thus smaller than $1/k = 0.125$. Therefore, the winning coalition does not set $\alpha_2 = 0$ but instead sets it at the larger value of $0.022 < \alpha_1$. It is important to note that, since the x_1-maximizing α_1 is conditional on the chosen z while this z value itself depends on α_1, the two values must be mutually consistent. Indeed, the x_1-maximizing α_1 value of 0.106 is conditional on a z value of 9.379, which in turn equals the chosen z value when $\alpha_1 = 0.106$. Thus, these z and α_1 values are mutually consistent and thus represent equilibrium values. Since efficient level of z, found by setting $\alpha_1 = 1/n$, equals 8.615, the equilibrium results in an 8.8% overprovision of the public good. Variation in the parameter values yield other equilibria with similar qualitative features.

Parameter variation under the assumed functional forms could not generate an equilibrium where x_1 is increasing beyond $\alpha_1 = 1/k$, in which case α_1 would be set at this value and α_2 set at zero. While other functional forms might lead to such an outcome, experimentation with

other forms for the two production functions was not fruitful.

6. Extensions

6.1. Size differences across jurisdictions

Suppose that jurisdictions are heterogenous in the sense that they have different populations. Despite this difference, each jurisdiction is assumed to elect a single legislator, approximately mirroring the structure of the US Senate. The economy contains n_ℓ large jurisdictions and $n_s = n - n_\ell$ small jurisdictions, with populations $\overline{L}_\ell$ and $\overline{L}_s < \overline{L}_\ell$.

Let $\widetilde{\alpha}_i$ and $\overline{L}_i$ denote the production share and population for jurisdiction i. The tilde on the α's differentiates these values from α_1 and α_2, which have been used to denote common production shares within groups of jurisdictions. In addition, let $\phi_i \equiv \phi(\overline{L}_i, \widetilde{\alpha}_i)$ denote profits minus the cost of z production in jurisdiction i:

$$\phi_i \;=\; \phi(\overline{L}_i, \widetilde{\alpha}_i) \;=\; \pi_i \;-\; w_i L_{zi} \;=\; f(\overline{L}_i - L_z(\widetilde{\alpha}_i z)) \;-\; \overline{L}_i f'(\overline{L}_i - L_z(\widetilde{\alpha}_i z)). \tag{24}$$

The ϕ expression is useful because jurisdiction j's x consumption can be written as

$$x_j \;=\; w_j \;+\; \sum_{i=1}^{n} \phi_i/\widehat{L} \;\equiv\; w_j \;+\; \Omega, \tag{25}$$

where $\widehat{L} = \sum_{i=1}^{n} \overline{L}_i$ is the economy's total population. Note that $\sum_{i=1}^{n} \phi_i/\widehat{L} \equiv \Omega$ is the same for each individual in the economy.

Differentiating ϕ_i in (24) yields $\partial\phi_i/\partial\overline{L}_i = -\overline{L}_i f''(\overline{L}_i - L_z(\widetilde{\alpha}_i z)) > 0$, so that ϕ_i rises with population. In addition, $\partial^2\phi/\partial\overline{L}_i\partial\widetilde{\alpha}_i > 0$ holds provided that $f''' > 0$, an assumption that was previously argued to be reasonable.[10] Therefore, when a jurisdiction's population rises, the change in ϕ_i is larger the larger is the jurisdiction's production share.

Consider a coalition of size m consisting of as many large jurisdictions as possible. If $m > n_\ell$, then the coalition consists of all large jurisdictions and $m - n_\ell$ small jurisdictions. If $m \le n_\ell$, the coalition consists only of large jurisdictions, with some large jurisdictions being outside the coalition. It can be shown (see section 2 of the appendix) that, starting from

equal production shares of $1/n$, the x levels of jurisdictions in the coalition increase when their common production share α_1 rises above $1/n$, with the common share α_2 of outside jurisdictions falling below $1/n$. As a result, the coalition will set $\alpha_1 > \alpha_2$, as in the homogeneous case.

Now consider whether it would be advantageous to the coalition to replace a large jurisdiction with a small one, which means setting the large jurisdiction's share at α_2 and a small jurisdiction's share at α_1. The swap affects wages in the jurisdictions that change places, but the effect on the remaining jurisdictions in the coalition arises only through the impact on Ω. It can be seen that the swap reduces Ω, reducing x consumption for the remaining coalition members, given (25).[11] Since these members will not support the swap, the following conclusion emerges:[12]

Proposition 7. *With population-size heterogeneity and $f''' > 0$, the equilibrium coalition contains as many large coalitions as possible. The coalition will consist only of large jurisdictions if its size m is less than n_ℓ, while it will contain all the large jurisdictions and some small ones if $m > n_\ell$.*

6.2. Jurisdictional differences in public-sector productity

Jurisdictions could also exhibit heterogeneity in the extent of their efficiency in producing the national public good. Rather than having the common production function $g(\cdot)$, the marginal productivity of public-sector labor could differ across jurisdictions. Using the previous example, some jurisdictions (presumably those with excellent universities) may be much better at carrying out cancer research than others. In this situation, higher z production would require less additional labor in a high-productivity jurisdiction, yielding less incremental tightening of the labor market and thus a smaller increase in the local wage. High-productivity jurisdictions would therefore have less incentive to raise their production shares than low-productivity jurisdictions, even though efficiency would require that they be favored in the allocation of production. Thorough investigation of the effects of differential productivity, however, would be complex and beyond the scope of the paper.

6.3. The effect of agency preferences

Our analysis of how production shares are determined can be extended to cover bureau-

cratic behavior. If the bureaucracy desires to maximize the level of z, as in many Leviathan-style models of government agencies, it could manipulate production shares in service of this goal, recognizing the need for a winning coalition.

Consider an agency (like the Pentagon) that has the authority to allocate production to p producing states and $n - p$ non-producing states, setting production shares at $1/p$ in the producing states. While the agency can choose p, it does not directly control the level of z, which is chosen by majority vote among the jurisdictions' representatives. But the agency can influence the chosen level of z by through its production assignments. To see how, suppose that as p declines, increasing the production share in the group of producing jurisdictions, the preferred z level in the group rises (an outcome that mirrors Proposition 3b).[13]

Since the support for z within the set of producing jurisdiction will increase as p falls, the Pentagon will want to keep the set as small as possible while still having that set constitute a political majority. The chosen set of producing jurisdictions will therefore have size k, the size of the minimum winning coalition.

This conclusion is unaffected if the Pentagon prefers both a higher z and the smallest possible p. Widely dispersed production could make the Pentagon's supervision of production more difficult, perhaps imposing extra time costs or reducing the quality of z. The Pentagon will again want to set $p \geq k$, so that z is chosen by the group of producing jurisdictions. But setting p above k is suboptimal because a smaller p leads to more concentration, which is preferred, and to a higher z, which is also preferred. Thus, p is set equal to k, as in the case where the agency just cares about z.

Therefore, when the agency controls the allocation of production across jurisdictions, the outcome mimicks one aspect of the coalitional equilibrium, with production concentrated in the set of k jurisdictions. However, because of the additional assumptions imposed to facilitate this discussion (zero shares in $n - p$ jurisdictions; the preferred z in producing jurisdictions falling with p), an attempt to compare the chosen z level to the one from the previous analysis would not be fruitful.

As legislators often have substantial powers of their own to set production shares, this analysis may not be very realistic. Rather, it highlights the difference between political decisions

and bureaucratic decisions, as in the public choice literature. But the discussion shows that, even though politicians and bureaucrats have different preferences, both groups are likely to prefer concentration of production in an inefficiently small number of jurisdictions. Legislators seek greater concentration to raise x consumption, while bureaucrats seek it to raise z.

In addition to agency bureaucrats, various interest groups, including weapons manufacturers or their agents, will attempt to influence production decisions. Such interest groups would also seek high levels of z, leading to outcomes similar to those under legislator or agency decisions. Thus, even if politicians, bureaucrats, and interest groups all have different preferences, their efforts may all lead in the same direction.

7. Empirical evidence

This section presents empirical evidence relevant to the model. The first subsection (7.1) derives the empirical hypothesis, but doing so requires information about the pattern of production shares in the data, which is not described in detail until the subsequent data subsection (7.2). But the key feature of the pattern, namely, that production is more concentrated than predicted by the model, is easily grasped, and it leads to a simple empirical prediction based on a more-fundamental implication of the model. With the prediction in hand, the nature of the data is then discussed in section 7.2, and results are presented in section 7.3

7.1. Derivation of the Empirical hypothesis

The model's predicted coalitional equilibrium, where a majority of jurisdictions have a production share greater than $1/n$, with the rest having a lower share, may not match actual outcomes. In particular, in the US state-level dataset described below, the pattern of production is much more concentrated than the one predicted by the model. The upshot is that the median production share among states is less than $1/n$, in contrast to the model's prediction of a median share greater than $1/n$. As a result, if the median jurisdiction is decisive, z would be chosen by states *outside* of the group where production is concentrated, in contrast to the outcome under our minimum winning coalition. This unpredicted concentration of production may arise because of various unmodeled political factors. For example, the recent theoretical work of Ali, Bernheim and Fan (2019), along with the empirical findings in Berry and Fowler

(2018), suggest that committee chairs in Congress are disproportionately important. With the committee chair likely to control the pattern of expenditures across jurisdictions, spending is likely to be skewed in favor of his jurisdiction and those of close allies. However, the median jurisdiction, despite its low spending share, may still help to determine the level of z. Thus, while the current model assumes that all jurisdictions are equally powerful, relaxing that assumption in this fashion is capable of overturning the model's predictions regarding the pattern of production shares.[14]

Even though the model's simple coalitional analysis turns out not be consistent with patterns in the data, it is still possible to empirically test its more-fundamental implication that the allocation of production across jurisdictions matters in determining the chosen level of a national public good. In particular, the analysis predicts that, in a situation where the median state share is realistically less than $1/n$, greater concentration of production will reduce z because it further lowers the share of the median jurisdiction.

To understand this conclusion, recall that Proposition 3b says that, whatever the sizes m and $n - m$ of the two groups of jurisdictions, the preferred z in the m group is increasing in its production share α_1 in the vicinity of equal shares. But the numerical example shows that this property extends all the way down to an initial production share of zero, so that the m-group's preferred z is increasing in its share for $\alpha_1 \in [0, 1/n]$. Thus, the numerical example says that, with an m-group whose members have a share less than $1/n$, a decrease in this production share due to greater concentration of production in the $n - m$ group will lead to a lower preferred z among m-group members and thus a lower chosen z when the m-group is realistically the majority. This conclusion also generalizes to a case with three rather two groups of jurisdictions.[15] Thus, the empirical hypothesis is that greater concentration of production will reduce z when production shares have a realistic pattern.

It is important to note that the *opposite prediction* would apply in a coalitional structure that follows the model. In this case, high-production-share jurisdictions would constitute a *majority*, not a minority, and greater concentration of production, by raising their shares, would *increase*, not decrease, their preferred level of z and thus z's chosen level. Therefore, in this alternate situation, an increase in concentration would *raise*, not lower, z. Because

the reality does not match this situation, the alternative hypothesis from above is the one tested. The test makes use of the Herfindahl index (HHI) of spending shares across states as a concentration measure, as explained further below. Since concentration rises with the HHI, the empirical prediction is that total spending across all states, the analog to z, is inversely related to the HHI.

To summarize, the actual pattern of production is typically more concentrated than the model predicts, an outcome that could be due to the power of Congressional committee chairs, control by bureaucrats with a strong preference for centralization, or other unmodelled factors. But it is still possible to test the model's more fundamental implication, which holds regardless of the nature of the political process that allocates production. This implication, namely, that the pattern of production determines political support for public spending, can be tested by looking for an inverse relationship between the concentration measure and total spending on the national public good.

7.2. Data

The hypothesis that political support depends on the location of production is tested using a panel of expenditures for different US federal programs within each state from 1983-2010. We focus on the program spending category that appears most appropriate for testing the model: spending on grants. The measure of z is total national grant spending for a program, and each program-year combination is a different observation in the data set.

As explained above, we use a Herfindahl index to capture the dispersion of spending for each of the sample years. Recognizing that the US Congress consists of two houses, we use two different Herfindahl indices. One is the between-state HHI, where each state's share of total program grant expenditure is used to construct the index (equal to the sum of squares of state shares of program grant spending).[16] The state Herfindahl index constructed in this way views the relevant jurisdictions as states, capturing the influence of the US Senate in spending decisions. Recognizing that some state spending shares may be zero, the HHI's dispersion measure captures both concentration of spending into states with nonzero shares as well as the dispersion of spending with this group of nonzero-share states

The other index is a Herfindahl index within states. That is, we construct an HHI based

on the distribution of a program's grant spending across counties within a state. This within-state Herfindahl captures the breadth of program spending across counties and thus the level of political support within a state. To create the regression variable, we average the within-state HHIs across states for each program used in the national regression. In constrast to the across-state HHI, the within-state HHI views the relevant jurisdictions as districts of the House of Representatives. These districts obviously do not correspond to counties, but the within-state HHI based on counties will give a rough approximation to a House-district-level HHI. Together, the across-state and within-state HHI variables capture two dimensions of the dispersion of program grant spending. Consistent with the theory, we find there is non-linearity in the impact of the Herfindahl index on total expenditures by program and thus estimate the equation using natural logs.[17]

Finally, we include program and year fixed effects in our empirical model, along with a program time trend. Elapsed time for a program is measured from the program's first year in the data, with the passage of time assumed to have a common effect across programs. Government programs may grow over time because the bureaucrats that administer a program learn to infuence the legislature. The time trend captures this potential impact, allowing the Herfindahl indices to therefore isolate the impact of program expenditure dispersion on total program spending.

The data come from the Certified Federal Funds Report (CFFR). This source shows program spending by jurisdiction, indicating the type of expenditure that occurs within each of nine categories.[18] We focus on the grants category, doing so in part because grants may be the closest analog to the national public goods envisioned in the model. By contrast, data for federal salaries and for procurement are considerably less useful than the grants data. These data are classified based on the agency controlling the expenditure, rather than the program purpose. Further, this information is collected over ten fewer years than for the other categories.[19] Thus, the category of federal grants best serves our needs, as the grants are classified according to each program and have data over the entire span 1983-2010.

To ensure a connection to the model, programs in the data set should arguably have some elements of a national public good. On the one hand, a program that directly benefits

specific groups may still be a national public good if other people care about the welfare of the affected individuals. For example, federal income redistributive programs such as Medicaid, which benefit the poor, may have this property. A health safety net in every jurisdiction may be highly valued across the nation, and (as in the model) it can only be delivered through widespread medical "production." Medical research fits the model even more closely, since production can occur in many regions while the total research output affects the quality of care throughout the country. On the other hand, provision of a good such as a highway to a local area may generate network externalities across the entire country, with long-distance travelers using local roads, while also generating local benefits. Education at all levels also has elements of a national public good since students educated in one place may move elsewhere, exposing other jurisdictions to the benefits of their human-capital acquisition. National parks and even state parks, by attracting visitors from across the country, also can be viewed as national public goods. Even further, provision of a local public good such as clean drinking water may have externalities arising through mobility of the population. That is, citizens of the country may desire that potable water is available in any area they might visit. We believe the theory developed above applies to any publicly provided good or service that generates such externalities, including income-redistributive programs, even though it might not exactly fit the canonical example of jet fighter production. As a result, we include all federal programs in the data set.

However, as a sensitivity test, we eliminate programs with (low) HHI values that are close to the Herfindahl index of the national population, which is based on state population shares. Grant expenditures on such low-HHI programs are distributed roughly proportionally to population, as with most income-redistributive programs. The sensitivity test thus excludes many such programs.

Descriptive statistics for the data are presented in Table 1. The data set contains 23,711 observations for 2,627 individual programs during the period 1983-2010. At 8,496, the mean within-state HHI (an average of the program's within-state HHIs) is considerably larger than the mean between-state HHI (equal to 2,309), possibly because many grants to states are recorded as being spent in the state capital, even if funds are later passed through to other

entities across the state. Our assumption is that this pattern is common across states, thus leading to a uniform bias in the magnitude of the variable.

The table also shows the sample-average Herfindahl index for state populations, equal to 435. Population is clearly much more widely distributed across states (leading to a lower HHI) than is the average allocation of grants (conversely, grant expenditures are more concentrated on average than the population). The table also shows that about half of the states receive grant funding from each program on average, and Figure 1 shows the distribution of state coverage across programs (the number of states, averaged over the sample years, with positive spending for a program). Note the spikes at 1 and 51, which indicate that many programs cover just a single state or cover all states (the District of Columbia is counted as a state). Figure 2 shows the distribution of the between-states HHI, with the index averaged across the sample years for each program. The spike at 10,000 reflects the single-state programs, while the large frequencies at low HHI values partly capture Figure 1's spike in all-states programs. Finally, the data means hint at the dynamic nature of programs passed by Congress. The average program length is 14 years, about half the length of the data panel, while 106 programs are in the data for all 28 years.

As explained above, the magnitude of the median state production (spending) share plays a crucial role in the empirical argument. The typical size of the median share is gauged by identifying the median spending share in a given year for each program, and then averaging the medians across programs for that year. This average of the program median values ranges between 0.004 and 0.006 across the sample years, being well below $1/n = 1/51$, which is close to 0.02. The small average of the medians arises because many programs have a median share of zero (where the median state receives no grant spending) and because, when the median share is positive, it is usually well below $1/n$. With production thus concentrated in a minority of states, greater concentration reduces the spending share of the median state, leading to a predicted reduction in z.

Table 2 presents the evolution of grant programs over time, with spending amounts converted to 2010 dollars using the urban CPI index from the Bureau of Labor Statistics. The table illustrates the considerable increase in the number of programs over the sample years

(growing by 250%), although the real average spending shows a more modest upward trend (growing by 22.7%). In 2010, the last year of our data, total federal expenditure on grant programs as categorized by the CFFR amounted to over $670 billion.

Table 3 shows the 10 largest grant programs in 2010, measured by total grant spending. As can be seen, many of these programs are income redistributive, and some involve little in the way of public production. The production side of TANF, for example, consists only of maintaining offices that oversee distribution of welfare funds. However, as explained above, most of the these programs are eliminated once minimum-HHI criteria are applied.

7.3. Results

The main regression results are presented in Table 4. The first column shows that greater between-state dispersion of funds in a program, leading to a 1% drop in the between-state HHI index, is associated with a 1.28% increase in program expenditure. The drop in the Herfindahl index could be caused by either an increase in the number of states receiving funds or a greater dispersion of funds across states that participate.

While this change holds the within-state HHI fixed, an increase in within-state dispersion of spending holding the between-state HHI fixed leads to a somewhat larger (though statistically indistinguishable) 1.53% increase in program spending. If we believe that the HHI indices capture political support in the Senate and House, respectively, it could be argued that the House is at least as important as the Senate in determining the level of programmatic spending. Finally, the insignificant time trend coefficient shows the absence of programmatic growth in real terms over time. The other two columns show that deletion of either the within-state HHI or the time trend leaves the other coefficients mostly unchanged, although the time trend coefficient gains significance in the second column.

An important robustness test is prompted by the fact that the between-state HHI is negatively correlated with the number of states with positive spending (the simple correlation is -0.70), as suggested both by intuition and by Figures 1 and 2. Since one might expect total grant spending for a program to rise with an increase in the number of positive-spending states, the negative HHI coefficients in the previous regressions could be spurious, being merely an artifact of this correlation rather evidence of the association predicted by the model. In

other words, with more positive states meaning more spending, the negative spending effect of HHI could simply be a result of the correlation with this omitted count of positive states. To evaluate this possibility, a variable equal to the number of states with positive spending, by program and year, is added to the basic regression of Table 4, with the results shown in Table 5. As can be seen, the between-state HHI coefficients in the three regressions remain negative, although their absolute magnitudes are cut by 2/3, revealing the expected downward bias in the original estimates. Therefore, holding the number of positive states constant, total grant spending remains negatively associated with the HHI concentration measure.

Table 6 shows the effects of eliminating low-HHI programs. The first column shows results for the first specification in Table 4 when attention is restricted to programs with HHI values greater than the sample-average population HHI of 435. This restriction reduces the number of programs slightly to 2,504 and has only small effects on the between-state and within-state HHI coefficients, relative to Table 4. Further restrictions to programs with HHI values larger than 1.5, 2, and 2.5 times the population HHI lead to only small further changes in the HHI coefficients, as seen in the remaining columns of Table 6. All the time trend coefficients in the table are insignificant, however. Therefore, removing low-HHI programs (as many as 600 in the last column of Table 6) has little effect on the conclusion that greater dispersion of program expenditures raises the overall level of program grant spending. This conclusion is thus robust to the inclusion or exclusion of income redistributive programs, which tend to be eliminated by the restriction. For example, of the ten largest programs under the restriction in the last column of Table 6, none are income redistributive.

Table 7 shows the effect of restricting attention programs with different durations or different state coverages. The first column shows regression results for the 377 programs that operate for at least 18 out the 28 sample years, and the HHI coefficients are similar to those in Table 3. The time trend coefficient, however, is again insignificant. The same qualitative conclusions emerge for 1,839 short-duration programs, those lasting for 10 or fewer years, as seen in the second column of the table.[20]

With the main conclusions thus robust to program duration, the remaining columns of Table 7 show the results of restrictions involving state coverage. The third column shows that,

when attention is restricted to the 1,352 programs covering at least 26 states, the between-state HHI coefficient becomes insignificant, although the within-state HHI coefficient remains significantly negative. However, this change disappears when attention is restricted to the 455 programs whose expansion leads them to eventually cover all 51 states (including the District of Columbia), as seen in the last column. For these widespread programs, incremental growth in state coverage, which tends to reduce between-state HHI, increases total program spending. Note that when attention is restricted to programs covering less than 26 states (the middle column of the table), the between-states HHI coefficient is again significantly negative. While one might think that this outcome is dependent on the high HHI in single-state programs, a significantly negative coefficient still emerges when the number of positive states is included as an additional covariate, matching the outcome in Table 5.

A further modification of the model involves the use of the median spending share by program and year as an explanatory variable in place of the HHI measures. Naturally, the two variables are negatively correlated (more concentration reduces the median share), and when the median share replaces the between-state HHI in the column-two regression of Table 4, its coefficient is significantly positive. This result, which matches the predictions of the model, further validates our approach. However, we prefer to use HHI as a right variable given that model's predictions are couched in terms of spending concentration.

8. Summary and conclusion

This paper has studied an overlooked phenomenon in the provision of public goods: local production of a national public good, such as national defense. The main implication of the analysis is that the pattern of production across jurisdictions affects political support for spending on the national good and thus the level chosen by the federal legislature. This support is generated via the income benefits that arise from local production.

We build a model in which local production of the national good tightens the local labor market, raising wages. In pursuit of these wage benefits, jurisdictions seek to raise their shares of the national good's production by joining a minimum winning coalition, which inefficiently raises the shares of members at the expense of nonmembers. Income benefits from the resulting

concentration of production reduce the perceived marginal cost of the public good within the winning coalition, leading to overprovision.

Our simple coalitional analysis is unable to capture the actual pattern of production in the data, which is more concentrated than predicted. But the model's more-fundamental implication, namely, that support for public spending depends on the pattern of production across jurisdictions, can be tested by looking for an inverse relationship between concentration and total spending on the national public good. This prediction holds regardless of the nature of the political process that governs the allocation of production.

The prediction is confirmed using data on federal grant expenditures under hundreds of federal programs, and it is robust across multiple program subsamples: programs with wide vs. narrow state coverage; short- vs. long-lived programs; programs that follow the distribution of population to a greater or lesser extent. The evidence is thus strongly consistent with view that support for spending on a national public good depends on the locational pattern of production. This is the main lesson of the paper.

Since the paper addresses a new topic in public economics, it opens many doors for further research. The model could be extended in many directions, particularly by making the political equilibrium more realistic, and additional empirical work could extend and refine the current results.

Appendix

1. The planning solution

The planner chooses x_1, L_{zi} (L_z in jurisdiction i), and z to maximize the Lagrangean expression

$$
\begin{aligned}
Q \;\equiv\; & u(x_1, z) \;+\; \sum_{i=2}^{n} \kappa_i [u(x_i, z) - \overline{u}_i] \;+\; \mu \left[\sum_{i=1}^{n} f(\overline{L} - L_{zi}) - \sum_{i=1}^{n} \overline{L} x_i \right] \\
& + \; \beta \left[\sum_{i=1}^{n} g(L_{zi}) - z \right] \;+\; \sum_{i=1}^{n} \gamma_i (\overline{L} - L_{zi}]. \qquad (a1)
\end{aligned}
$$

where μ, β, λ_i, and γ_i are multipliers. The first summation captures the utility constraints for consumers $2, 3, \ldots, n$, and the term multiplying μ captures the constraint on overall x consumption, which must equal the total production across all the jurisdictions. The term multiplying β captures the requirement that z equals the sum of production levels across jurisdictions, and last term in $(a1)$ captures constraints on the L_{zi}, which cannot be larger than $\overline{L}$.

The first-order conditions are

$$
x_1: \quad \frac{\partial Q}{\partial x_1} \;=\; u_{1x} \;-\; \overline{L}\mu \;=\; 0 \qquad (a2)
$$

$$
x_i: \quad \frac{\partial Q}{\partial x_i} \;=\; \kappa_i u_{ix} \;-\; \overline{L}\mu \;=\; 0, \quad i = 2, 3, ..., n. \qquad (a3)
$$

$$
L_{iz}: \quad \frac{\partial Q}{\partial L_{iz}} \;=\; -\mu f'(\overline{L} - L_{iz}) \;+\; \beta g'(L_{iz}) \;-\; \gamma_i \;=\; 0, \quad i = 1, 2, 3, ..., n. \qquad (a4)
$$

$$
z: \quad \frac{\partial Q}{\partial z} \;=\; u_{1z} \;+\; \sum_{i=2}^{n} \kappa_i u_{iz} \;-\; \beta \;=\; 0. \qquad (a5)
$$

If the Inada conditions

$$
lim_{\ell \to 0} f'(\ell) \;=\; \infty, \qquad lim_{\ell \to 0} g'(\ell) \;=\; \infty \qquad (a6)
$$

are satisfied, then $L > L_{iz}$ holds in $(a4)$ and hence $\gamma_i = 0$, $i = 1, 2, \ldots, n$. As a result, $(a4)$ can be rearranged to read

$$\frac{f'(\overline{L} - L_{zi})}{g'(L_{zi})} \;=\; \frac{\beta}{\mu}, \quad i = 1, 2, 3, ..., n. \qquad (a6)$$

Since $f'(L - L_{iz})/g'(L_{iz})$ is monotonically increasing in L_{zi}, there is a unique value of L_{zi}, denoted L^*_{zi}, that satisfies $(a6)$. More importantly $L^*_{zi} = L^*_z$, $i = 1, 2, 3, ..., n$, so that equal production shares are efficient.

Note from $(a2)$, $(a3)$ and $(a5)$ that β/μ equals $n\overline{L}u_z/u_x$, with u_z/u_x uniform across jurisdictions, while $f'/g' = f'L'_z$, with f' equal to the wage under decentralization. Therefore, $(a6)$ coindicides with the generalized version of the decentralized first-order condition (17) from the text.

When population varies across jurisdictions, $\overline{L}$ in $(a6)$ is replaced by $\overline{L}_i$, with the condition implying that the optimal L_{zi} is not constant but an increasing function of $\overline{L}_i$. Therefore, unequal production shares become efficient, although assigning zero shares to some jurisdictions, as occurs in the heterogenous equilibrium, remains inefficient.

2. The effect of increasing α_1 in the hetergeneous case

To demonstrate that an increase in α_1 is beneficial for a coalition containing as many large jurisdictions as possible, let ℓ_1 and s_1 denote the numbers of large and small jurisdictions in the coalition, and let ℓ_2 and s_2 be the corresponding numbers outside the jurisdiction. Note that if the coalition contains only large jurisdictions, then $\ell_2 \geq 0$ and $s_1 = 0$, whereas $s_1 > 0$ and $\ell_2 = 0$ hold if the coalition contains both large and small jurisdictions.

Letting ϕ_ℓ and ϕ_s denote ϕ values for large and small jurisdictions, Ω can be written as

$$\Omega \;=\; \ell_1\phi_\ell \;+\; s_1\phi_s \;+\; \ell_2\phi_\ell \;+\; s_2\phi_s \qquad (a7)$$

when evaluated at $\alpha_1 = \alpha_2$, in which case ϕ_ℓ and ϕ_s take the same value inside and outside the coalition.

Differentiating $(a7)$ with respect to α_1 yields

$$\frac{\partial \Omega}{\partial \alpha_1} \;=\; \ell_1 \frac{\partial \phi_\ell}{\partial \alpha_1} \;+\; s_1 \frac{\partial \phi_s}{\partial \alpha_1} \;+\; \left[\ell_2 \frac{\partial \phi_\ell}{\partial \alpha_2} \;+\; s_2 \frac{\partial \phi_s}{\partial \alpha_2} \right] \frac{\partial \alpha_2}{\partial \alpha_1}. \qquad (a8)$$

Substituting $\partial\alpha_2/\partial\alpha_1 = -m/(n-m)$, (a8) reduces to

$$\left(\ell_1 - \ell_2 \frac{m}{n-m} \right) \frac{\partial \phi_\ell}{\partial \alpha_1} \;+\; \left(s_1 - s_2 \frac{m}{n-m} \right) \frac{\partial \phi_s}{\partial \alpha_2}. \qquad (a9)$$

To sign $(a9)$, consider first the case where the coalition contains only large jurisdictions $(s_1 = 0,\ \ell_2 \geq 0)$. Then, noting that $m = \ell_1 + s_1$ and $n - m = \ell_2 + s_2$, the first term in parentheses in $(a9)$ equals $\ell_1 - \ell_2(\ell_1/(\ell_2 + s_2))$, which is proportional to $\ell_1 s_2 > 0$. Recalling that $\partial\phi_\ell/\partial\alpha_1 > \partial\phi_s/\partial\alpha_1$, $(a9)$ is then greater than

$$\left(\ell_1 - \ell_2 \frac{m}{n-m} \right) \frac{\partial \phi_s}{\partial \alpha_1} \;+\; \left(s_1 - s_2 \frac{m}{n-m} \right) \frac{\partial \phi_s}{\partial \alpha_2}. \qquad (a10)$$

Note in $(a10)$ that $\partial\phi_s/\partial\alpha_1$ replaces $\partial\phi_\ell/\partial\alpha_1$ from $(a9)$. Since $(a10)$ is evaluated at $\alpha_1 = \alpha_2$, it follows that $\partial\phi_s/\partial\alpha_2 = \partial\phi_s/\partial\alpha_1$. Making this substitution in $(a10)$ and gathering terms, the expression equals zero, implying $\partial\Omega/\partial\alpha_1 > 0$.

A similar calculation applies to the case where the coalition contains large and small jurisdictions $(\ell_2 = 0, s_1 > 0)$. The first term in $(a9)$ is again positive, and substitutions like those leading to $(a10)$ show that $(a9)$ is once again positive, implying $\partial\Omega/\partial\alpha_1 > 0$ in this case as well.

3. Effects of production shares on z with three groups

Suppose there are 3 groups of states with shares equal to $(\alpha, \beta, 0)$ and numbers equal to (n_α, n_β, n_0), where

$$n_\alpha \alpha \;+\; n_\beta \beta \;=\; 1 \qquad (a11)$$

$$n_\alpha \;+\; n_\beta \;+\; n_0 \;=\; n \qquad (a12)$$

$$\alpha \;>\; \beta \;> 0 \qquad (a13)$$

Profits and taxes are again equally shared, and per capita profit and per capita tax are

$$\pi(z,\alpha,\beta) \equiv \frac{n}{\overline{L}}\{n_\alpha[f(\overline{L}-L_z(\alpha z)) - f'(\overline{L}-L_z(\alpha z))(\overline{L}-L_z(\alpha z))] + n_\beta[f(\overline{L}-L_z(\beta z)) - f'(\overline{L}-L_z(\beta z))(\overline{L}-L_z(\beta z))]\} \quad (a14)$$

$$T(z,\alpha) \equiv \frac{n}{\overline{L}}[n_\alpha f'(\overline{L}-L_z(\alpha z))L_z(\alpha z) + n_\beta f'(\overline{L}-L_z(\beta z))L_z(\beta z)]. \quad (a15)$$

Private good consumption of a jurisdiction with share $s = (\alpha, \beta, 0)$ is given by

$$\begin{aligned} x_s &\equiv f'(\overline{L}-L_z(sz)) + \pi(z,\alpha,\beta) + T(z,\alpha,\beta) \\ &= f'_s + \frac{n}{\overline{L}}\{n_\alpha[f_\alpha - f'_\alpha \overline{L}] + n_\beta[f_\beta - f'_\beta \overline{L}]\}, \quad s = \alpha, \beta, 0, \end{aligned} \quad (a16)$$

where the subscripts on f and f' denote the share contained in the function's argument.

Suppose that the decisive/median jurisdiction has share $s = \alpha, \beta, 0$. Then, the public good z is chosen to maximize the decisive state's utility $U(x_s, z)$, satisfying the first-order condition

$$U_z + U_x \frac{\partial x_s}{\partial z} = 0, \quad s = \alpha, \beta, 0. \quad (a17)$$

Let $z^*(s)$ denote the z value satisfying the $(a17)$.

Suppose that a β-state is the median/decisive state. The effect of an increase in α (along with a decrease in β) on $z^*(\beta)$ is

$$\frac{\partial z^*(\beta)}{\partial \alpha} \simeq U_{zx}\frac{\partial x_\beta}{\partial \alpha} + U_x \frac{\partial}{\partial \alpha}\left(\frac{\partial x_\beta}{\partial z}\right) + U_{xx}\frac{\partial x_\beta}{\partial \alpha}\frac{\partial x_\beta}{\partial z} < 0 \quad if \quad (a18)$$

$$f' > 0,\ f'' < 0,\ f''' > 0,\ f'''' < 0, \quad and \quad g(L_z) = L_z^\eta,\ \eta \in (0,1), \quad and \quad U_{xz} \geq 0. \quad (a19)$$

Therefore, under the given (plausible) conditions, an increase in concentration that shifts production away from a decisive state that itself has a positive production share leads to reduction in z.

If a 0-state is instead the median/decisive state, then exactly same conclusion holds. That is, $\partial z^*(0)/\partial\alpha < 0$ holds if the assumptions in ($a19$) are satisfied. Therefore, an increase in concentration due to a shift in production between the positive-share states reduces the preferred z of a decisive zero-share state, thus reducing the z that is chosen.

A third possible change is an increase in α when an α-state is the median/decisive state. This change is analogous to the one in Proposition 3b, except that in this case, it occurs in the presence of zero-share states. A set of conditions exists that yields $\partial z^*(\alpha)/\partial\alpha > 0$, matching the conclusion in the text. However, the first two cases, where a low-share jurisdiction is decisive and concentration is increased by an increase in the share of the high-share jurisdiction, are the cases that are empirically relevant. In both these cases, concentration and the level of z are inversely related.

Table 1: Descriptive Statistics

Variable	# of observations	Mean	Std. Dev.
Grant Spending per Program	23,711	209	2,570
Herfindahl–Between States	23,711	2,308.66	2,906.72
Herfindahl–Within States (avg.)	23,711	8,496.37	1,887.08
Number of States in Program	23,711	26.55	18.45
Average Time Trend	23,711	7.54	6.32
Herfindahl of State Populations	28	434.04	6.68
Average Program Length	2,627	8.35	7.42

Note: Data is for years 1983-2010. Amounts are in millions of 2010 US dollars. Observations are programs times years for the category "Grants to Institutions." The between-state Herfindahl index is calculated as the squared sum of state shares times 100, so that the maximum value is 10,000. The within-state Herfindahl indices are calculated by county within each state, and averaged over the states for each program. The Herfindahl index for state population is for comparison purposes only. Average program length is in years. Time trend variables is 1 for the first year, 2 for the second and so on, for each program. 205 program-year observations are deleted that do not have programs defined.

Table 2: Grant Programs by Year

Year	*# of Programs*	*Average Amount* (2010$m)	*Total Spending* (2010$m)
1983	494	442.5	218,596
1984	526	416.2	218,907
1985	544	403.1	219,294
1986	599	384.2	230,121
1987	601	363.0	218,136
1988	629	358.3	225,402
1989	656	342.5	224,674
1990	714	333.9	238,412
1991	747	354.2	264,582
1992	780	384.0	299,523
1993	803	428.7	344,234
1994	869	413.8	359,626
1995	906	401.6	363,874
1996	845	418.7	353,786
1997	873	420.2	366,797
1998	912	414.5	378,056
1999	898	445.9	400,416
2000	910	465.3	423,388
2001	916	483.7	443,057
2002	933	528.3	492,860
2003	955	538.7	514,442
2004	979	528.5	517,440
2005	969	531.2	514,718
2006	982	523.2	513,742
2007	1,082	474.9	513,892
2008	1,135	496.1	563,034
2009	1,217	580.0	705,916
2010	1,237	543.0	671,691
Total	23,711		

Table 3: Largest Programs

Program	*Total National Spending* ($ *billion*)
Women, Infants and Children (WIC)	6.3
Head Start	6.6
Title I Education Aid (low income)	7.5
Education Jobs Fund	8.8
Children's Health (CHIP)	10.8
Special Education Grants to States	11.3
School Lunch	15.0
TANF	16.7
Section 8 Housing Vouchers	17.8
Highway Construction	46.5
Medicaid	285.0

Table 4: Basic Regression Results

Variable	*total spending*	*total spending*	*total spending*
HHI–Between States	-1.277***	-1.382***	-1.276***
	(0.037)	(0.038)	(0.037)
HHI–Within States (avg.)	-1.528***		-1.539***
	(0.155)		(0.154)
Program Time Trend	0.003	0.007**	
	(0.003)	(0.003)	
Observations	23,711	23,711	23,711
R-squared	0.418	0.362	0.416
Number of Programs	2,627	2,627	2,627

All variables except the time trend are in natural logs. Regressions include fixed effects for programs and years. Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5: Basic Model Plus Number of Positive States

Variable	*total spending*	*total spending*	*total spending*
HHI–Between States	-0.401***	-0.405***	-0.400***
	(0.045)	(0.046)	(0.045)
HHI–Within States (avg.)	-0.824***		-0.831***
	(0.126)		(0.125)
Number of Positive States	0.081***	0.086***	0.081***
	(0.003)	(0.003)	(0.003)
Program Time Trend	0.002	0.004*	
	(0.002)	(0.002)	
Observations	23,711	23,711	23,711
R-squared	0.550	0.530	0.550
Number of Programs	2,627	2,627	2,627

All variables except the time trend and number of positive states are in natural logs. Regressions include fixed effects for programs and years. Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6: Regression Results Excluding Low-HHI Programs

Variable	Program HHI > Pop HHI *total spending*	Program HHI > 1.5×Pop HHI *total spending*	Program HHI > 2×Pop HHI *total spending*	Program HHI > 2.5×Pop HHI *total spending*
HHI–Between States	-1.294***	-1.334***	-1.338***	-1.395***
	(0.041)	(0.046)	(0.048)	(0.052)
HHI–Within States (avg.)	-1.783***	-1.870***	-1.731***	-1.767***
	(0.184)	(0.236)	(0.258)	(0.299)
Program Time Trend	0.004	0.003	0.003	0.004
	(0.003)	(0.004)	(0.005)	(0.006)
Observations	20,101	15,731	12,730	10,746
R-squared	0.425	0.356	0.319	0.295
Number of Programs	2,506	2,323	2,151	2,006

All variables except the time trend are in natural logs. Regressions include fixed effects for programs and years. Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7: Regression Results for Programs with Different Durations and State Coverages

Variable	$\geq$ 18 years *total spending*	$\leq$ 10 years *total spending*	$\geq$ 26 states *total spending*	$<$ 26 states *total spending*	eventually reach all 51 states *total spending*
HHI-Between States	-1.074***	-1.312***	-0.0368	-1.232***	-1.507***
	(0.080)	(0.050)	(0.063)	(0.041)	(0.078)
HHI-Within States (avg.)	-1.447**	-1.056**	-0.911***	-1.335***	-1.206***
	(0.219)	(0.230)	(0.165)	(0.239)	(0.230)
Program Time Trend	0.004	0.008	0.014***	0.005	0.005
	(0.003)	(0.008)	(0.002)	(0.004)	(0.004)
Observations	8,664	8,906	12,039	11,672	6,084
R-squared	0.318	0.374	0.076	0.212	0.214
Number of Programs	377	1,839	1,352	2053	455

All variables except the time trend are in natural logs. Regressions include fixed effects for programs and years. Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

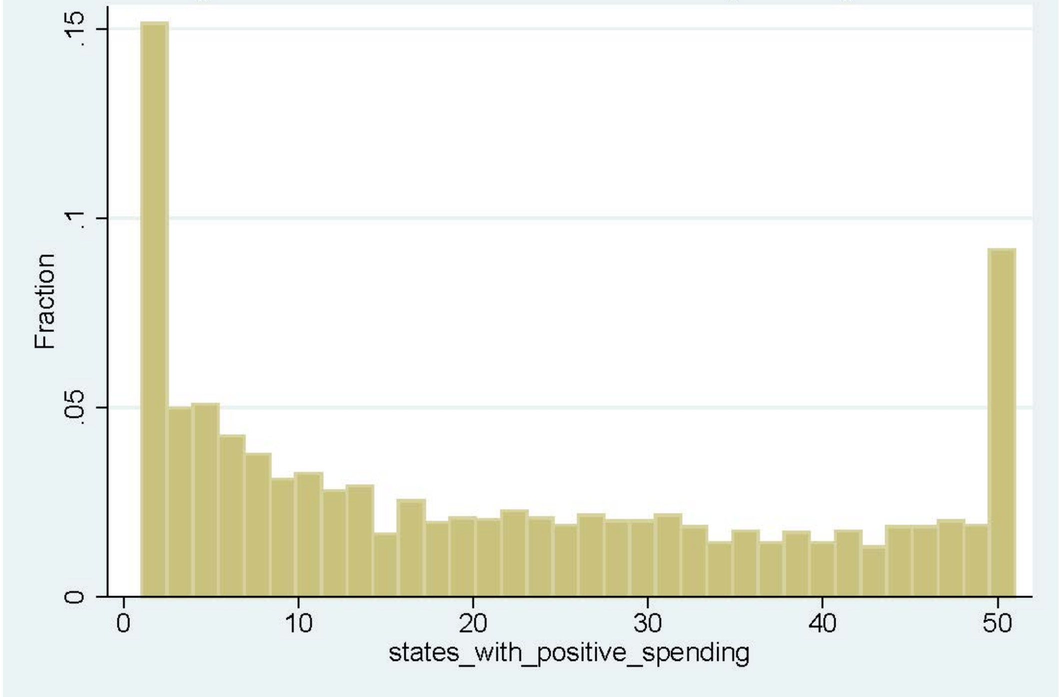
Figure 1: Distribution of Positive-Spending States
Fraction
0
.05
.1
.15
0
10
20
30
40
50
states_with_positive_spending

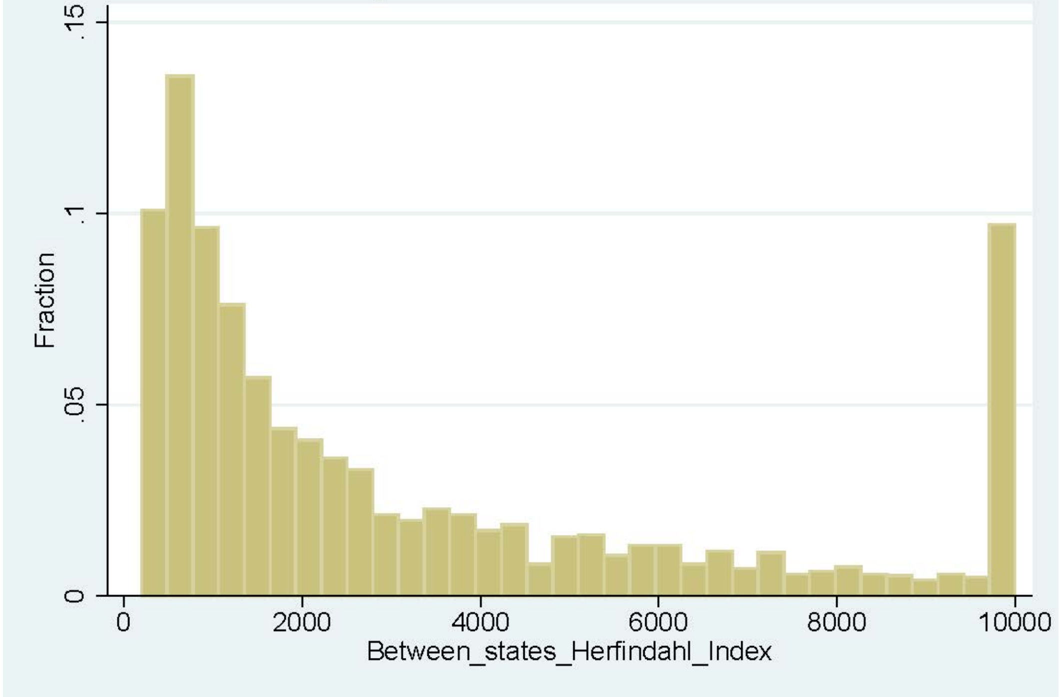
Figure 2: Distribution of HHI
Fraction
0
.05
.1
.15
0
2000
4000
6000
8000
10000
Between_states_Herfindahl_Index

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Footnotes

*We thank Bruno de Borger, Stephen Coate, Ami Glazer, Willem Sas, and Albert Solé-Ollé for helpful comments.

[1]In a *Vox* story about the new F-35 fighter, which has encountered design problems and large cost overruns, Ellis (2017) echoes this view, as follows:

"But at this point, the F-35 can't be canceled. That's because, while the plane itself may be poorly designed, how the plane is built was perfectly designed. The F-35 project was intentionally designed to have stakeholders in Congress, the economy, and the military–a group informally known as the military-industrial complex. All of them have a lot to lose if the project fails, and they will fight tooth and nail to protect Lockheed Martin no matter how poorly the project is going. It's a strategy called political engineering, and all the major defense companies use it.

One thing every member of Congress can support is jobs in their district. So major US defense contractors spread their operations across as many states as possible, because the more districts they have employees in, the more legislators will fight to protect those jobs and the programs that support them."

[2]The outcome can be viewed as an inefficient form of income redistribution across jurisdictions, which is achieved by distorting the pattern of public production. See Coate and Morris (1995) for an analysis of inefficient redistribution favoring interest groups.

[3]A number of models are related, albeit not directly, to the present one. Besley and Coate (2003) add spillover effects and study how the behavior of the legislature of locally elected representatives affectsthe efficiency of allocation of public goods. Lizzeri and Persico (2001) compare a winner-take-all system and a proportional system with regard to the level of public good provision. Volden and Wiseman (2007) consider both public and private goods in a model of bargaining in legislatures. A number of papers empirically test models of legislative bargaining. DelRossi and Inman (1999) explore the relationship between local cost shares and legislators' demands for public projects. Bradbury and Craine (2001) examine the effects of the number of representatives on the level of public spending. Lazarus (2008) studies politicians' electoral vulnerability and the federal spending they secure. DeBacker (2011) estimates the influence of seniority on the allocation of federal funds. Hodler and Raschky (2014) test for regional favoritism by relating the birthplaces of politicians to nighttime light intensity based on satellite data, a measure of economic activity.

[4]Manipulation of (9) and (10) shows that the difference between x consumption and production jurisdiction 1 is $\overline{L}x_1 - f_1 = \frac{1}{2}[f_2 - f_1 + \overline{L}(f_1' - f_2')] > 0$ when $\alpha_1 > 1/2$. The expression for $\overline{L}x_1 - f_1$, which comes from reversing the subscripts, is negative.

[5]These coalitions can be viewed as emerging in the same way as those in the well-known legislative bargaining paper of Baron and Ferejohn (1989). In particular, a legislator is randomly chosen to make a proposal specifying production shares and z. The proposal attracts the votes of a majority of jurisdictions, which thus can be viewed as constituting a coalition even though explicit coordination is not involved.

[6]Note that the same x_1 outcome could be achieved by maintaining $\alpha_1 = \widehat{\alpha}_1$ but setting the coalition size above k but below the value $1/\widehat{\alpha}_1$, where α_2 would equal zero. Since such a choice would lead to a worse outcome (with α_2 lower) for coalition nonmembers with no benefit to the coalition, it would not be selected.

[7]Despite the parallel noted in footnote 5, this framework is in some ways much more restrictive than the one proposed in Baron and Ferejohn (1989). Their study analyzes a legislature's allocation of a fixed amount of resources across jurisdictions, a problem somewhat similar to the choice of production shares, although simpler. However, their framework includes multiple periods and has no restriction on the allocation pattern across jurisdictions. In the resulting equilibrium, the proposing jurisdiction gives a positive allocation to itself and positive but smaller amounts to $k-1$ other jurisdictions, while the remaining jurisdictions receive nothing. The restrictions in the current framework avoid the complexities of Baron and Ferejohn's analysis while leading to an equilibrium similar to theirs.

[8]The resulting value of $\overline{\alpha}$ from (23) is again assumed to lie in the range where x_1 is increasing in $\overline{\alpha}$.

[9]When $\alpha_1(z)$ represents an interior solution, satisfying $\partial x_1/\partial \alpha_1 = 0$, the vanishing of z's effect on α_1 follows from the envelope theorem (in section 5.1, this is the case where $\alpha_1 = \hat{\alpha}$). In the alternate case where the optimal α_1 equals $1/k$, a value independent of z, the effect of z on α_1 once again vanishes.

[10]$\partial^2 \phi(\overline{L}_i, \widetilde{\alpha}_i)/\partial \overline{L}_i \partial \widetilde{\alpha}_i \;=\; \overline{L}_i f'''(\overline{L}_i - L_z(\widetilde{\alpha}_i z)) z L_z' \;>\; 0.$

[11]The change in Ω as a result of the swap is equal to

$$[\phi(\overline{L}_\ell, \alpha_2) + \phi(\overline{L}_s, \alpha_1)] \;-\; [\phi(\overline{L}_\ell, \alpha_1) + \phi(\overline{L}_s, \alpha_2)] \;=$$

$$[\phi(\overline{L}_\ell, \alpha_2) - \phi(\overline{L}_s, \alpha_2)] \;-\; [\phi(\overline{L}_\ell, \alpha_1) - \phi(\overline{L}_s, \alpha_1)] \;<\; 0. \qquad (f1)$$

Note that in the first line of $(f1)$, the large (small) jurisdiction originally has a production share of α_1 (α_2), and that the shares are switched after the swap. In addition, the second line of $(f1)$ follows from $\partial^2\phi/\partial \overline{L}_i \partial \widetilde{\alpha}_i > 0$. The inequality in $(f1)$ assumes that α_1 and α_2 are sufficiently close that only first-order effects need be considered.

[12]If both large jurisdictions and small jurisdictions are in the same winning coalition, they need

not necessarily have the same production shares if the equal-share assumption is relaxed. It is even quite possible that the large members get shares of $1/n_\ell$ while small members get nothing. The reason is that if small jurisdictions create another coalition with more small jurisdictions, they would get a positive share and thus be better off due to higher wages, but the common income part, $\sum_{i=1}^{n} \phi_i/nL$, would decrease due to an increase in the number of small jurisdictions getting positive productions shares. So, in general, large jurisdictions would tend to get larger shares than small ones with relaxation of the equal-share assumption. Details would depend on the magnitude of n_ℓ and the shapes of f and g.

[13]This pattern cannot be established in general, partly because the production share outside the p-group of jurisdictions is zero rather than $\alpha_2 > 0$, as in Proposition 3b. However, we suppose for illustrative purposes that the preferred z in producing jurisdictions rising as p falls

[14]The analysis of Ali et al. (2018) is based on the predictability of future proposers of legislation. As long as some proposers can be ruled out, Ali et al. show that the current proposer (the committee chair) will wield the most influence, and that the remaining members of the minimum winning coalition will be those that can be induced to join at lowest cost. Berry and Fowler (2018), using several different measures of Congressional influence, including campaign contributions, lobbyist interactions, and an index of legislative influence, find that the chairs of important committees are much more important than other members of Congress.

[15]The appendix shows that this conclusion emerges in a more realistic jurisdictional configuration with three groups: one having a high production share, a second having a low production share, and third having a zero share. If the median (and thus decisive) jurisdiction belongs to either the low-share or zero-share group, which is the empirically relevant case, then an increase in concentration due to an increase in the share of the high-share group reduces the chosen z. Thus, concentration and the level of z continue to be inversely related in this more complex configuration.

[16]We multiply shares by 100 for convenience, so that the maximum index value if all expenditure is in a single state is 10,000.

[17]For example, in linear regressions both the linear and squared Herfindahl indices are statistically and quantitatively significant, with a maximum effect near the maximum of the Herfindahl indices. Thus, we believe the log specification more closely captures the empirical regularity.

[18]The categories are direct payments for individuals (broken into retirement and disability payments or other payments), direct payments other than for individuals, grants (block

grants, formula grants, project grants, and cooperative agreements), procurement contracts, salaries and wages, direct loans, guaranteed/insured loans, and insurance.

[19]The CFFR data collection program was cancelled by the Obama administration in 2010.

[20]Some of these programs may already have been operating at the beginning of our data, but all terminate during the 1983-2010 period.