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 reduce 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).

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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 level of spending is inefficiently high in pork-barrel models, just as in our model, but the sources of this distortion are different. In the pork-barrel model, each of the \(n\) jurisdictions helps pay for spending that yields purely local benefits in a single jurisdiction. With the receiving jurisdiction thus paying only \(1/n\) of the cost, its preferred spending level is far above the efficient level, where benefits and costs would be equated. By contrast, overprovision arises in our model because of the local income benefits from concentrated production of the public good. In a jurisdiction with a high production share, these benefits help to offset the cost of provision of the good, thus reducing its perceived marginal cost. This cost reduction arises
through the local labor market, not from cost-sharing with other jurisdictions. Moreover, because our inefficiency is due to the concentration of production, it vanishes when production is equally distributed, whereas pork-barrel inefficiency is always present.

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, which show where federal funds are spent in the US. We focus on expenditures on 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). Our measure of spending concentration is the Herfindahl-Hirschman index (HHI) based on state-level program grant expenditures, and our test asks whether a lower concentration of grant expenditure for a program (a lower HHI) is associated with greater overall program spending on grants.

Unobservable program characteristics may affect both the level of spending and spending concentration, leading to negative correlation between HHI and the regression error term. As a result, we estimate both ordinary and two-stage least squares regressions relating overall program spending to concentration. The instrument for a program’s HHI is the average HHI for programs in the same broad grouping. Mirroring the OLS estimates, the 2SLS results show that overall program expenditure is inversely related to HHI, showing the causal relationship predicted by the theory.

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 jurisdiction’s 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

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

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

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

Differentiation of $g(L_z) = z$ shows that $L_z' = 1/g' > 0$ and $L_z'' = -(1/g'')g''L_z' > 0$, 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 (\( L^\tau_x \), 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

\[
I(z) = w(z) + \pi(z)/L, \quad T(z) = w(z)L_z(z)/\bar{L}, \tag{5}
\]

with \( \pi/L \) 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 \( z \):

\[
I' = w' + \frac{\pi'}{L} = \frac{w'L - w'L_x}{L} = \frac{w'L_z}{\bar{L}} > 0. \tag{6}
\]

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),

$$x' = \frac{w' L_z}{L} - \frac{(w' L_z + w L'_z)}{L} = -\frac{w L'_z}{L}.$$  \hspace{1cm} (7)

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

$$\frac{L u_z}{u_x} = \frac{w L'_z}{L}.$$  \hspace{1cm} (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 $w' L_z / L$, 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

\[
T(z, \alpha_1) = \frac{w(\alpha_1 z) L_z(\alpha_1 z) + w((1 - \alpha_1) z) L_z((1 - \alpha_1) z)}{2L},
\]

where \( 2L \) 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

\[
I_1(z, \alpha_1) = w(\alpha_1 z) + \frac{\pi(\alpha_1 z) + \pi((1 - \alpha_1) z)}{2L},
\]

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

\[
\frac{\partial I_1(z, \alpha_1)}{\partial z} = \alpha_1 w'_1 - \frac{\alpha_1 w'_1 L_{z1} + (1 - \alpha_1) w'_2 L_{z2}}{2L},
\]

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

\[
\frac{\hat{\alpha} w'((\hat{\alpha} z)) L_z((\hat{\alpha} z))}{L}.
\]

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

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

\[
\frac{\partial T(z, \alpha_1)}{\partial z} = \frac{\alpha_1 w'_1 L_{z1} + \alpha_1 w_1 L'_{z1} + (1 - \alpha_1) w'_2 L_{z2} + (1 - \alpha_1) w_2 L'_{z2}}{2L},
\]
Again evaluating under symmetry, (13) reduces to

\[ \hat{\alpha} [w'(\hat{\alpha}z)L_z(\hat{\alpha}z) + w(\hat{\alpha}z)L'_z(\hat{\alpha}z)] \]

\[ \frac{1}{L} \]  

(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

\[ \left. \frac{\partial x(z, \alpha_1)}{\partial z} \right|_{\alpha_1 = \hat{\alpha}} = \left( \frac{\partial I_1(z, \alpha_1)}{\partial z} - \frac{\partial T(z, \alpha_1)}{\partial z} \right) \right|_{\alpha_1 = \hat{\alpha}} = - \frac{\hat{\alpha} w(\hat{\alpha}z)L'_z(\hat{\alpha}z)}{L}, \]  

(15)

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

\[ 2\frac{L}{\hat{\alpha}} \frac{u_z}{u_x} = wL'_z, \]  

(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 \(-L(\alpha_1 w'_1 - (1 - \alpha_1) w'_2)\), 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 $\alpha_1$. Accordingly, consider the effect on $x_1 \equiv x(z, \alpha_1)$ of an increase in $\alpha_1$. To start, the income expression in (10) is differentiated with respect to $\alpha_1$, yielding

$$\frac{\partial I_1}{\partial \alpha_1} = zw_1' - \frac{zw_1' L_{x_1} - zw_2' L_{x_2}}{2L} = \frac{z}{2L} [w_1'(2L - L_{x_1}) + w_2' L_{x_2}] > 0, \quad (17)$$

so that jurisdiction 1’s income rises with its production share. The $\alpha_1$-derivative of the tax expression in (10) is

$$\frac{\partial T}{\partial \alpha_1} = \frac{zw_1' L_{z_1} + z w_1' L_{x_1}'}{2L} - \frac{zw_2' L_{z_2} + z w_2' L_{x_2}'}{2L} \quad (18)$$

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 $\alpha_1$-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 \( \alpha_1 \) 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 \( \alpha_1 \) 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 \( \alpha_1 \) diverges from 1/2. The approach is to differentiate (16) with respect to \( \alpha_1 \) and then deduce the direction of \( \alpha_1 \)’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 \( \alpha_1 \)-derivative of (19) yields the direction of the effect on \( z \).

The \( \alpha_1 \)-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 $\alpha_1$-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 $\alpha_1$ derivatives of (11) and (13). It is easy to see that the derivative of $\partial T/\partial z$ in (13) with respect to $\alpha_1$ is zero when evaluated under equal shares ($\alpha_1 = \hat{\alpha}$), a consequence of the offsetting changes in $\alpha_1$ and $1-\alpha_1$. Therefore, the $\alpha_1$-derivative of $\partial I_1/\partial z$ in (11) determines the sign of the desired derivative. Once again, the $\alpha_1$-derivative of the ratio term in (11) is zero under equal shares because of the offsetting changes in $\alpha_1$ and $1-\alpha_1$. Thus, only the first term in (11) ($\alpha_1 w'_1$) contributes to the derivative, so that

$$\frac{\partial^2 x(z, \alpha_1)}{\partial z \partial \alpha_1}|_{\alpha_1=\hat{\alpha}} = \frac{\partial^2 I_1}{\partial z \partial \alpha_1}|_{\alpha_1=\hat{\alpha}} = w'_1(\hat{\alpha}z) + \hat{\alpha}zw''_1(\hat{\alpha}z) > 0. \quad (20)$$

Combined with the earlier conclusion that $\partial MRS/\partial \alpha_1$ is positive, the upshot is that the $\alpha_1$-derivative of the entire expression in (19) is positive. With (19) then increasing in $\alpha_1$, 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 $\alpha_1$. The following conclusion can then be stated:

**Proposition 2.** Jurisdiction 1’s preferred level of $z$ is increasing in its public-good production share $\alpha_1$ when $\alpha_1$ 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 $\alpha_1$ 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 $\alpha_1$ 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 \( \alpha_1 \) and that the remaining \( n - m \) each have a production share of \( \alpha_2 \). Individual income in jurisdiction 1 is then

\[
I_1 = w(\alpha_1 z) + \frac{m\pi(\alpha_1 z) + (n-m)\pi(\alpha_2 z)}{nL},
\]

while the tax payment is

\[
T = \frac{mw(\alpha_1 z)L_z(\alpha_1 z) + (n-m)w(\alpha_2 z)L_z(\alpha_2 z)}{nL}.
\]

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 \( \alpha_1 \). Then

(a) the \( m \)-group’s \( x \) consumption is increasing in its production share \( \alpha_1 \) for \( 0 \leq \alpha_1 \leq 1/n \) and for a range above \( 1/n \).

(b) the \( m \)-group’s preferred \( z \) level is increasing in \( \alpha_1 \) when \( \alpha_1 \) 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 $\alpha_1$ for jurisdictions within the coalition, as well as a uniform share of $\alpha_2$ 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 $m \geq k$.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 $\alpha_1$ and $z$ by the winning coalition, but where the choice is decomposed into two stages, with $\alpha_1$ chosen conditional on $z$ and $z$ then chosen in a first stage, taking account of its effect on the optimal $\alpha_1$. 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 $\alpha_1$, 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 $\alpha_1$, making use of the envelope theorem. The following analysis focuses on the choice of $\alpha_1$, 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 $\alpha_1$ 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 $\alpha_1$ marginally above $1/n$ while setting $\alpha_2$, the common nonmember share, marginally below $1/n$.

However, the coalition members may benefit from further increases in $\alpha_1$ beyond this initial marginal change, with appropriate adjustment of $\alpha_2$. The details depend on the behavior of $x_1$ as the production share $\alpha_1$ 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 $\alpha_1$ value of $\alpha^*$, this coalition does not have a winning size.

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

**Proposition 4.** The equilibrium coalition has size \( k \) and sets the common production share \( \alpha_1 \) for its members above \( 1/n \), with \( \alpha_2 \) set below \( 1/n \). If \( x_1 \) is maximized at an \( \alpha_1 \) 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 \( \alpha_1 \). 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 \( \lambda \) (\( \lambda < 1/n \) must hold). The coalition will then never wish to set a production share \( \alpha_1 \) so high that the gap between the shares exceeds \( \lambda \). With a coalition size of \( m \), the \( \alpha_1 \) value where the gap equals \( \lambda \), denoted by \( \overline{\alpha} \), is determined by the condition \( m\overline{\alpha} + (n - m)(\overline{\alpha} - \lambda) = 1 \). Solving for \( \overline{\alpha} \) yields

\[
\overline{\alpha}(m) = \frac{1}{n} + \frac{n - m}{n}\lambda,
\]

so that \( \overline{\alpha} \), which depends on \( m \), equals \( 1/n \) plus a fraction of the maximal gap \( \lambda \).
If \( \lambda \) is sufficiently small, then difference between \( \bar{\alpha} \) and \( 1/n \) from (23) is small enough that the coalition’s \( x_1 \) value is guaranteed to increase with \( \alpha_1 \) over the interval \([1/n, \bar{\alpha}]\), by Proposition 3a. As a result, the coalition will set \( \alpha_1 = \bar{\alpha}(m) \), leading to the maximal gap \( \lambda \) 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), \( \bar{\alpha}(m) \) 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 \( \alpha_2 = \bar{\alpha}(k) - \lambda = 1/n - (k/n) \lambda \).

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 \( \alpha_1 \) conditional on \( z \). As usual in a two-stage depiction of a simultaneous optimization problem, the effect of \( z \) on \( \alpha_1 \) 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 \( \alpha_1 \) is sufficiently close to \( 1/n \) (as would occur, for example, when \( \lambda \) 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 \( \alpha_1 \) 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 \( \alpha_2 \) 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 $(1/nL)$ 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 $\alpha_1$ 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 $\alpha_1$ is conditional on the chosen $z$ while this $z$ value itself depends on $\alpha_1$, the two values must be mutually consistent. Indeed, the $x_1$-maximizing $\alpha_1$ 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 $\alpha_1$ 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 $\alpha_1$ would be set at this value and $\alpha_2$ 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 heterogeneous 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 $n_\ell$ large jurisdictions and $n_s = n - n_\ell$ small jurisdictions, with populations $\overline{L}_\ell$ and $\overline{L}_s \prec \overline{L}_\ell$.

Let $\tilde{\alpha}_i$ and $\overline{L}_i$ denote the production share and population for jurisdiction $i$. The tilde on the $\alpha$'s differentiates these values from $\alpha_1$ and $\alpha_2$, which have been used to denote common production shares within groups of jurisdictions. In addition, let $\phi_i \equiv \phi(\overline{L}_i, \tilde{\alpha}_i)$ denote profits minus the cost of $z$ production in jurisdiction $i$:

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

The $\phi$ expression is useful because jurisdiction $j$'s $x$ consumption can be written as

$$x_j = w_j + \sum_{i=1}^{n} \phi_i/\overline{L} \equiv w_j + \Omega, \quad (25)$$
where \( \hat{L} = \sum_{i=1}^{n} \overline{L}_i \) is the economy’s total population. Note that \( \sum_{i=1}^{n} \phi_i/\hat{L} \equiv \Omega \) is the same for each individual in the economy.

Differentiating \( \phi_i \) in (24) yields
\[
\partial \phi_i / \partial \overline{L}_i = -\overline{L}_i f''(\overline{L}_i - L_z(\overline{\alpha}_i z)) > 0,
\]
so that \( \phi_i \) rises with population. In addition, \( \partial^2 \phi / \partial \overline{L}_i \partial \overline{\alpha}_i > 0 \) 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 \( \phi_i \) 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 \( m \leq n_\ell \), 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 \( \alpha_1 \) rises above \( 1/n \), with the common share \( \alpha_2 \) 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 \( \alpha_2 \) and a small jurisdiction’s share at \( \alpha_1 \). 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 \( \Omega \). It can be seen that the swap reduces \( \Omega \), 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 \( n_\ell \), while it will contain all the large jurisdictions and some small ones if \( m > n_\ell \).

6.2. Jurisdictional differences in public-sector productivity

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 bureaucratic 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 subsection 7.2, and results are presented in subsection 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.  

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 $\alpha_1$ 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.$^{15}$

Thus, the empirical hypothesis is that greater concentration of production will reduce $z$ when production shares have a realistic pattern.$^{16}$ In effect, we are testing Proposition 3b (extended via the simulation analysis), which continues to be valid even if the coalitional predictions of Proposition 4 are not upheld by the data. 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.

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.

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.$^{17}$ 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.$^{18}$ 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.

As explained above, we use a Herfindahl index to capture the dispersion of a program’s spending for each of the sample years. Each state’s share of total program grant expenditure is used to construct the HHI measure, equal to the sum of squares of state shares of program grant spending in a given year. Shares are multiplied by 100 for convenience, so that the index value equals 10,000 when all expenditure is concentrated in a single state.$^{19}$ It is important
to note that, since some state spending shares may be zero, the HHI's dispersion measure captures concentration of spending into states with nonzero shares as well as the dispersion of spending within this group of positive-spending states. Since we find non-linearity in the impact of the Herfindahl index on total expenditures, consistent with theory, we estimate the equation using natural logs.  

Finally, we include program and year fixed effects in our empirical model, along with a variable counting the years since initiation of the program. 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 influence 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.

Since the Herfindahl index is potentially correlated with the regression error term, as explained previously, we present 2SLS results along with OLS estimates. The instrument for a program's HHI is the average HHI value by year among programs with the same first digit in the five-digit program code (the own HHI is excluded in computing the average). These first-digit groupings show substantial variation in the average HHI values (with the average computed across years and programs in the group), even though separation into groups is not particularly intuitive. As a result, the instrument is a good predictor of the individual program HHI in a given year, and because it aggregates across many programs (leaving out the own program), it is likely to be uncorrelated with shocks at the individual program level that affect overall spending in a program. This lack of correlation might disappear with a finer group breakdown by agency, given that other-program HHIs might be correlated with the spending error term for a particular program due to common interagency shocks.

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. The mean of the program HHI values is 2,309.66, indicating a moderate degree of spending concentration.

The table also shows the sample-average Herfindahl index for state populations, equal to 434. 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 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 these programs are eliminated once minimum-HHI criteria are applied.

7.3. Results

The basic regression results are presented in Table 4, where the log of overall program spending is the dependent variable. The first column, which reports the OLS results, shows a negative and strongly significant log HHI coefficient, consistent with the predictions of the theory. The estimated coefficient indicates that a 1% increase in the Herfindahl index, implying greater spending concentration, is associated with a 1.38% decline in program expenditure. Conversely, greater dispersion of spending, resulting in a 1% decrease in the HHI, leads to a 1.38% increase in program expenditure. Note that the increase in the Herfindahl index could be caused by either a decrease in the number of states receiving funds or greater concentration of spending within the group of participating states. The positive and significant coefficient on years since program initiation shows that programs grow in real terms over time, as expected. An extra year of program longevity raises spending by 0.7%.

The 2SLS results, which are shown in column 2 of the table, use an instrument for HHI equal to the average HHI of programs in the same spending area (with the own HHI excluded), as explained above. The resulting HHI values have a much smaller standard deviation than HHI itself (see Table 1), a consequence of using approximate averages in place of the actual HHI values. Using the log of this measure as an instrument for log HHI yields the 2SLS results in the table, which again show a negative and strongly significant log HHI coefficient, while indicating a greater concentration effect than the OLS estimate. The implication is that the OLS results are upward biased, although the exact mechanism leading to this bias is hard to identify. The Cragg-Donald F statistic is large, showing that the instrument is strong. The years-since-initiation coefficient is again positive and significant, while slightly larger than the OLS value.

Table 5 shows the effects of eliminating low-HHI programs, using 2SLS regressions that omit the positive-states variable, matching the specifications in Table 4. The first column shows results when attention is restricted to programs with HHI values greater than the sample-average population HHI of 434. This restriction reduces the number of programs slightly to 2,102 and has only small effects on the estimated 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 (the F statistic is large in all regressions). Therefore, removing low-HHI programs (as many as 600 in the last column of Table 6) has little effect on the conclusion that greater concentration of program expenditures lowers the overall level of 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.

As explained above, variation in HHI comes both from differences across programs in the number of states covered and from different degrees of spending concentration within the positive-spending states. The theory implies that concentration from both sources should reduce spending, and the regressions in Table 6 explore this issue. The first column, which shows an OLS regression of overall program spending on the number of positive states, illustrates the obvious point that programs covering more states spend more. The second regression, which again uses OLS, includes both log HHI and the number of positive states as covariates along with years since initiation. As can be seen, the coefficient of log HHI remains negative, although it is smaller in absolute value than in the OLS regression of Table 4, while the positive-states coefficient is slightly lower than in the first column. The regression thus shows that, holding the number of positive states constant, greater spending concentration within this set of states reduces overall program spending, as predicted. The fact that the coefficient of log HHI moves closer to zero makes sense given that the number of positive states is now doing part of the work in explaining variation in overall spending.

These results are also important because they show that the qualitative effect of HHI from Table 4 is not a spurious consequence of omitted-variable bias. To see this point, suppose that the model were incorrect, with spending rising with number of positive states but HHI having no independent spending effect, holding positive states constant. Then, because HHI and the number of positive states are negatively correlated (the simple correlation is $-0.70$), a regression of overall spending on log HHI could produce a negative (rather than zero) coefficient as a result of negative correlation between log HHI and the error term, which includes positive
states. This finding would provide false confirmation of theory. By showing that the log HHI coefficient remains significantly negative even when positive states is added to the regression, the results in column 2 of Table 5 discount this possibility, providing further support for the theory.

Ideally, the regression in column 2 should account for potential endogeneity of both log HHI and the number of positive states. However, the last column of Table 5 shows that this step is not entirely successful. The instrument for the number of positive states is computed using the previous approach, being set equal to the average number of positive states from programs in the same spending area (with the own value omitted). Even though the positive-states coefficient is (unsurprisingly) positive when the column-1 regression is estimated by 2SLS, the coefficients of both positive states and log HHI are insignificant when they appear together in a 2SLS regression, as seen in the last column of the table. Their signs, however, are unchanged relative to the OLS regression. This outcome is not particularly surprising given the need to instrument two of the three covariates (in effect, we are asking too much of the data, as reflected in the low F statistic shown in the table). As a result, we put more credibility in the OLS results of column 2 in further supporting the theory.

As a final sensitivity test, Table 7 shows regression results when the set of grant programs is restricted to those from agencies providing public goods that are arguably national (this selection of agencies is obviously open to debate). These agencies are the Departments of Defense, Justice, State, Transportation, Energy, and Homeland Security, the National Science Foundation, National Endowments of Humanities and Arts, and the Agency for International Development. As can be seen, the results mostly replicate the earlier ones. Although none of the years-since-initiation coefficients is significant, the log HHI coefficients in first two columns show the same pattern as in Table 4, and the last two columns match the coefficient patterns in the last two regressions in Table 6. The similarity of results might suggest that the full set of programs can also be viewed as providing national public goods, as argued above.

Overall, the results in Tables 4–7 provide evidence of a causal link between spending concentration and the overall level of grant expenditure for government programs, providing support for the theory developed in the paper. The empirical model can actually be modified to
offer one last piece of support by replacing the HHI variable with the median spending share by program and year. Naturally, the two variables are negatively correlated (more concentration reduces the median share), and when the median share replaces HHI in the regressions, 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 use of instrumental variables methods allows us to conclude that the link between overall expenditures and spending concentration is causal. 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.

One of the important byproducts of our work is that it illustrates an overlooked drawback to a federalist system of government, which is felt at the national level. Although our exact coalition predictions are not upheld in the data, the theory nevertheless points to a tendency toward overprovision of national public goods via the high local production shares engineered by winning jurisdictions, a distortion that is evidently hard to circumvent. This finding along with other insights offered by paper open the door to extensions in many directions, which could include a more realistic portrayal of the political equilibrium along with empirical work exploring other economic consequences of local production.
Appendix

1. The planning solution

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

$$Q \equiv u(x_1, z) + \sum_{i=2}^{n} \kappa_i[u(x_i, z) - \bar{u}_i] + \mu \left[\sum_{i=1}^{n} f(L - L_{zi}) - \sum_{i=1}^{n} Lx_i\right]$$

$$+ \beta \left[\sum_{i=1}^{n} g(L_{zi}) - z\right] + \sum_{i=1}^{n} \gamma_i(L - L_{zi}).$$

(a1)

where $\mu, \beta, \lambda_i,$ and $\gamma_i$ are multipliers. The first summation captures the utility constraints for consumers 2, 3, ..., $n$, and the term multiplying $\mu$ captures the constraint on overall $x$ consumption, which must equal the total production across all the jurisdictions. The term multiplying $\beta$ 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 $L$.

The first-order conditions are

$$x_1 : \quad \frac{\partial Q}{\partial x_1} = u_{1x} - L\mu = 0$$

(a2)

$$x_i : \quad \frac{\partial Q}{\partial x_i} = \kappa_i u_{ix} - L\mu = 0, \quad i = 2, 3, ..., n.$$  \hspace{1cm} (a3)

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

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

If the Inada conditions

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

(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

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

(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 $L_{zi}^* = L_x^*$, $i = 1, 2, 3, \ldots, n$, so that equal production shares are efficient.

Note from (a2), (a3) and (a5) that $\beta/\mu$ equals $nL u_z/u_x$, with $u_z/u_x$ uniform across jurisdictions, while $f'/g' = f'L_x^*$, with $f'$ equal to the wage under decentralization. Therefore, (a6) coincides with the generalized version of the decentralized first-order condition (17) from the text.

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

2. The effect of increasing $\alpha_1$ in the heterogeneous case

To demonstrate that an increase in $\alpha_1$ is beneficial for a coalition containing as many large jurisdictions as possible, let $\ell_1$ and $s_1$ denote the numbers of large and small jurisdictions in the coalition, and let $\ell_2$ 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 $\phi_\ell$ and $\phi_s$ denote $\phi$ values for large and small jurisdictions, $\Omega$ can be written as

$$
\Omega = \ell_1 \phi_\ell + s_1 \phi_s + \ell_2 \phi_\ell + s_2 \phi_s
$$

(a7)

when evaluated at $\alpha_1 = \alpha_2$, in which case $\phi_\ell$ and $\phi_s$ take the same value inside and outside the coalition.
Differentiating \( (a7) \) with respect to \( \alpha_1 \) yields

\[
\frac{\partial \Omega}{\partial \alpha_1} = \ell_1 \frac{\partial \phi_\ell}{\partial \alpha_1} + s_1 \frac{\partial \phi_s}{\partial \alpha_1} + \left[ \ell_2 \frac{\partial \phi_\ell}{\partial \alpha_2} + s_2 \frac{\partial \phi_s}{\partial \alpha_2} \right] \frac{\partial \alpha_2}{\partial \alpha_1}. \tag{a8}
\]

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

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

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

\[
\left( \ell_1 - \ell_2 \frac{m}{n - m} \right) \frac{\partial \phi_\ell}{\partial \alpha_1} + \left( s_1 - s_2 \frac{m}{n - m} \right) \frac{\partial \phi_s}{\partial \alpha_2}. \tag{a10}
\]

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 \( (n_\alpha, n_\beta, n_0) \), where

\[
n_\alpha \alpha + n_\beta \beta = 1 \tag{a11}
\]
\[
n_\alpha + n_\beta + n_0 = n \tag{a12}
\]
\[
\alpha > \beta > 0 \tag{a13}
\]
Profits and taxes are again equally shared, and per capita profit and per capita tax are

\[ \pi(z, \alpha, \beta) \equiv \frac{n}{L} \left\{ n_\alpha [f(T - L_z(\alpha z)) - f'(T - L_z(\alpha z))(T - L_z(\alpha z))] + n_\beta [f(T - L_z(\beta z)) - f'(T - L_z(\beta z))(T - L_z(\beta z))] \right\} \]

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

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

\[ x_s \equiv f'(T - L_z(sz)) + \pi(z, \alpha, \beta) + T(z, \alpha, \beta) \]

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

\[ U_z + U_x \frac{\partial x_s}{\partial z} = 0, \quad s = \alpha, \beta, 0. \]

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

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

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

\[ f' > 0, \quad f'' < 0, \quad f''' > 0, \quad \text{and} \quad g(L_z) = L_\eta, \quad \eta \in (0, 1), \quad \text{and} \quad U_{xz} \geq 0. \]

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 $\alpha$ when an $\alpha$-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

<table>
<thead>
<tr>
<th>Variable</th>
<th># of observations</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grant Spending per Program</td>
<td>23,711</td>
<td>455</td>
<td>5,590</td>
</tr>
<tr>
<td>Herfindahl index</td>
<td>23,711</td>
<td>2,308.66</td>
<td>2,906.72</td>
</tr>
<tr>
<td>Years since initiation</td>
<td>23,711</td>
<td>7.54</td>
<td>6.32</td>
</tr>
<tr>
<td>Number of States with Positive Spending</td>
<td>23,711</td>
<td>26.55</td>
<td>18.45</td>
</tr>
<tr>
<td>Herfindahl of State Populations</td>
<td>28</td>
<td>434.04</td>
<td>6.68</td>
</tr>
<tr>
<td>Average Program Length</td>
<td>2,627</td>
<td>8.35</td>
<td>7.42</td>
</tr>
<tr>
<td>HHI instrument</td>
<td>23,700</td>
<td>2308.95</td>
<td>719.60</td>
</tr>
<tr>
<td>Positive-states instrument</td>
<td>23,700</td>
<td>26.55</td>
<td>4.58</td>
</tr>
</tbody>
</table>

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. 205 program-year observations are deleted that do not have programs defined. The instruments have slightly fewer observations since program areas with a single observation in a year cannot be included.
Table 2: Grant Programs by Year

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

Total 23,711
<table>
<thead>
<tr>
<th>Program</th>
<th>Total National Spending ($ billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women, Infants and Children (WIC)</td>
<td>6.3</td>
</tr>
<tr>
<td>Head Start</td>
<td>6.6</td>
</tr>
<tr>
<td>Title I Education Aid (low income)</td>
<td>7.5</td>
</tr>
<tr>
<td>Education Jobs Fund</td>
<td>8.8</td>
</tr>
<tr>
<td>Children’s Health (CHIP)</td>
<td>10.8</td>
</tr>
<tr>
<td>Special Education Grants to States</td>
<td>11.3</td>
</tr>
<tr>
<td>School Lunch</td>
<td>15.0</td>
</tr>
<tr>
<td>TANF</td>
<td>16.7</td>
</tr>
<tr>
<td>Section 8 Housing Vouchers</td>
<td>17.8</td>
</tr>
<tr>
<td>Highway Construction</td>
<td>46.5</td>
</tr>
<tr>
<td>Medicaid</td>
<td>285.0</td>
</tr>
</tbody>
</table>
Table 4: Basic results

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>log HHI</td>
<td>-1.382**</td>
<td>-2.389**</td>
</tr>
<tr>
<td></td>
<td>(0.0380)</td>
<td>(0.151)</td>
</tr>
<tr>
<td>Years since initiation</td>
<td>0.00709**</td>
<td>0.00858**</td>
</tr>
<tr>
<td></td>
<td>(0.00277)</td>
<td>(0.00161)</td>
</tr>
<tr>
<td>Observations</td>
<td>23,711</td>
<td>23,326</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.383</td>
<td>–</td>
</tr>
<tr>
<td>Number of programs</td>
<td>2,627</td>
<td>2,253</td>
</tr>
<tr>
<td>Cragg-Donald F statistic</td>
<td>–</td>
<td>269.07</td>
</tr>
</tbody>
</table>

Dependent variable is log of total program spending.
Regressions include program and year fixed effects.
log HHI is instrumented in (2).
The number of observations drops in (2) from the elimination of singleton-group observations.
Robust standard errors in parentheses
** p<0.01, * p<0.05
Table 5: Regressions excluding low-HHI programs

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) $\text{HHI} \geq \text{HHI}_{pop}$</th>
<th>(2) $\text{HHI} \geq 1.5 \times \text{HHI}_{pop}$</th>
<th>(3) $\text{HHI} \geq 2.0 \times \text{HHI}_{pop}$</th>
<th>(4) $\text{HHI} \geq 2.5 \times \text{HHI}_{pop}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>log HHI</td>
<td>-2.483** (0.170)</td>
<td>-2.753** (0.203)</td>
<td>-3.016** (0.255)</td>
<td>-3.280** (0.343)</td>
</tr>
<tr>
<td>years since initiation</td>
<td>0.00922** (0.00199)</td>
<td>0.00942** (0.00268)</td>
<td>0.0125** (0.00354)</td>
<td>0.0135** (0.00437)</td>
</tr>
<tr>
<td>Observations</td>
<td>19,686</td>
<td>15,253</td>
<td>12,209</td>
<td>10,230</td>
</tr>
<tr>
<td>Number of programs</td>
<td>2,102</td>
<td>1,852</td>
<td>1,638</td>
<td>1,495</td>
</tr>
<tr>
<td>Cragg-Donald F statistic</td>
<td>225.61</td>
<td>187.22</td>
<td>145.99</td>
<td>99.74</td>
</tr>
</tbody>
</table>

Dependent variable is log of total program spending.
Regressions include program and year fixed effects.
log HHI is instrumented in (1), (2), (3) and (4).
Robust standard errors in parentheses.
** p<0.01, * p<0.05
Table 6: Basic model plus number of positive states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>OLS</td>
<td>2SLS</td>
</tr>
<tr>
<td>log HHI</td>
<td>–</td>
<td>-0.405**</td>
<td>-1.700</td>
</tr>
<tr>
<td></td>
<td>(0.0452)</td>
<td>(1.117)</td>
<td></td>
</tr>
<tr>
<td>positive states</td>
<td>0.107**</td>
<td>0.0858**</td>
<td>0.0446</td>
</tr>
<tr>
<td></td>
<td>(0.00221)</td>
<td>(0.00302)</td>
<td>(0.0700)</td>
</tr>
<tr>
<td>years since initiation</td>
<td>0.00339</td>
<td>0.00431</td>
<td>0.00687*</td>
</tr>
<tr>
<td></td>
<td>(0.00231)</td>
<td>(0.00230)</td>
<td>(0.00322)</td>
</tr>
<tr>
<td>Observations</td>
<td>23,711</td>
<td>23,711</td>
<td>23,326</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.506</td>
<td>0.519</td>
<td>–</td>
</tr>
<tr>
<td>Number of programs</td>
<td>2,627</td>
<td>2,627</td>
<td>2,253</td>
</tr>
<tr>
<td>Cragg-Donald F statistic</td>
<td>–</td>
<td>–</td>
<td>4.10</td>
</tr>
</tbody>
</table>

Dependent variable is log of total program spending.
Regression includes program and year fixed effects.
log HHI and positive states are instrumented in (3).
Robust standard errors in parentheses
** p<0.01, * p<0.05
**Table 7: Results for selected agencies**

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>2SLS</td>
<td>OLS</td>
<td>2SLS</td>
</tr>
<tr>
<td>log HHI</td>
<td>-1.452**</td>
<td>-3.479**</td>
<td>-0.435**</td>
<td>-2.325</td>
</tr>
<tr>
<td></td>
<td>(0.0745)</td>
<td>(0.276)</td>
<td>(0.0871)</td>
<td>(17.07)</td>
</tr>
<tr>
<td>positive states</td>
<td>-</td>
<td>-</td>
<td>0.0880**</td>
<td>0.0615</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.00594)</td>
<td>(0.906)</td>
</tr>
<tr>
<td>years since initiation</td>
<td>0.00248</td>
<td>0.0102</td>
<td>-0.00199</td>
<td>0.00541</td>
</tr>
<tr>
<td></td>
<td>(0.00747)</td>
<td>(0.00536)</td>
<td>(0.00638)</td>
<td>(0.0709)</td>
</tr>
<tr>
<td>Observations</td>
<td>4,898</td>
<td>4,820</td>
<td>4,898</td>
<td>4,820</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.377</td>
<td>–</td>
<td>0.503</td>
<td>–</td>
</tr>
<tr>
<td>Number of programs</td>
<td>568</td>
<td>490</td>
<td>568</td>
<td>490</td>
</tr>
<tr>
<td>Cragg-Donald F statistic</td>
<td>–</td>
<td>93.98</td>
<td>–</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Dependent variable is log of total program spending. Regressions include program and year fixed effects.
log HHI is instrumented in (2).
log HHI and positive states are instrumented in (4).
Included agencies are Departments of Defense, Justice, State, Transportation, Energy, and Homeland Security, National Science Foundation, National Endowments for the Humanities and Arts, and Agency for International Development.
The number of observations drops in (2) and (4) from the elimination of singleton-group observations.
Robust standard errors in parentheses
** p<0.01, * p<0.05
References


Ellis, S., 2017. This jet fighter is a disaster, but Congress keeps buying it. *Vox*, https://www.vox.com/videos/2017/1/30/14382686/jet-fighter-f35-congress-trump


Knight, B., 2008. Legislative representation, bargaining power and the distribution of federal


Footnotes

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

1In 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.”

2The 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.


4Manipulation of (9) and (10) shows that the difference between $x$ consumption and production jurisdiction 1 is $L x_1 - f_1 = \frac{1}{2} [f_2 - f_1 + L(f_1' - f_2')] > 0$ when $\alpha_1 > 1/2$. The expression for $L x_2 - f_2$, which comes from reversing the subscripts, is negative.
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.

Note that the same $x_1$ outcome could be achieved by maintaining $\alpha_1 = \hat{\alpha}_1$ but setting the coalition size above $k$ but below the value $1/\hat{\alpha}_1$, where $\alpha_2$ would equal zero. Since such a choice would lead to a worse outcome (with $\alpha_2$ lower) for coalition nonmembers with no benefit to the coalition, it would not be selected.

Despite the parallel noted in footnote 5, this framework differs from that of Baron and Ferejohn (1989) in a number of directions. 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.

The resulting value of $\pi$ from (23) is again assumed to lie in the range where $x_1$ is increasing in $\pi$.

When $\alpha_1(z)$ represents an interior solution, satisfying $\partial x_1/\partial \alpha_1 = 0$, the vanishing of $z$’s effect on $\alpha_1$ 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 $\alpha_1$ equals $1/k$, a value independent of $z$, the effect of $z$ on $\alpha_1$ once again vanishes.

The change in $\Omega$ as a result of the swap is equal to

$$\phi(\bar{L}_{\ell}, \bar{\alpha}_i) - \phi(\bar{L}_s, \alpha_1) \quad \text{and} \quad \phi(L_{\ell}, \alpha_2) - \phi(L_s, \alpha_2) \quad \text{are sufficiently close that only first-order effects need be considered.}$$

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 $1/n_L$ 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 higher costs of public good production arising from the small jurisdiction sizes combined with decreasing returns to scale. 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 $g$.

13This 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.

14The 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.

15The 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.

16It is important to note that the opposite prediction would apply in a coalesional 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, $z$.

17The 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.
The CFFR data collection program was cancelled by the Obama administration in 2010.

We also experimented with a second Herfindahl index that measures the average dispersion of spending within states, which may affect political support within the House of Representatives. The index is based on a program’s county-level spending shares, and in a given year, it equals the average across states of the within-state HHI values. Since this variable, when paired with the between-states HHI value, does not perform well in the 2SLS regressions, it is not used in the empirical analysis. We believe this poor performance is due to a flaw in the county-level data, in that pass-through grants are coded as going to the state capital city rather than their actual destination.

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.

Group 1 consists of the Departments of Agriculture (with an average of 78 programs across years), Commerce (56), Defense (18), Housing and Urban Development (165), Interior (72), Labor (25), State (15); Group 2 consists of the Departments of Transportation (29) and two other small entities; Group 3 consists of only small entities; Group 4 consists of the National Science Foundation (11), the National Endowments for the Humanities and Arts (41), and two other small entities; Group 5 consists of the Small Business Administration (6) and two other smaller entities; Group 6 consists of the Department of Veterans Affairs (5) and the Environmental Protection Agency (67); Group 7 consists of the Nuclear Regulatory Commission (9) and another smaller entity; Group 8 consists of the Departments of Energy (31) and Education (149) and several other smaller entities; Group 9 consists of the Departments of Health and Human Services (222) and Homeland Security (40), Agency for International Development (11), and several other smaller entities. Note that the number of groups (nine) is coincidentally the same as the number of spending categories (see footnote 17).