Public Goods in Federal Systems*

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Abstract

We study a politico-economic model of federations with both federal and supplemental regional provision of a local public good with spillover effects. Regional differences in median income levels and externalities of provision induce differences in preferences over federal and regional levels of provision. Although the voters' preferences are not single-peaked, we provide sufficient conditions for the existence of a voting equilibrium and characterize its properties under alternative federal institutional arrangements. We show that the inter-regional redistributive tensions present in federations lead to differences in regional preferences over federal institutions and may explain otherwise puzzling patterns in state support for federal programs.

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Introduction

The issue of the composition and structure of political unions or federations is as timely as it has ever been, with the expansion of the European Union leading to some of the most heated debates in European politics in the last decade. In many cases of political unions, the joint action of the members is a function of distinctly political phenomena, such as the perception of a common military threat or the political salience of domestic ethnic groups with cultural or historic affinities for neighboring states. The unions that lead to the creation of common political institutions charged with the implementation of common economic policies are, however, rarely products of political calculations alone (see, e.g., Inman and Rubinfeld 1998, Emerson et al. 1988 for the EU, and Hardin 1999, Ch. 3, for the US), and call for the analysis of distinctly political-economic mechanisms of their formation, maintenance, and internal organization.

The present paper analyzes one such mechanism by considering the political and economic incentives within federal structures with public good provision on both local and federal levels and spillover effects between regions - features that often characterize contemporary federal systems, including the US, Germany, increasingly the EU, and many others. We show that, in the presence of income heterogeneity across regions, the dual structure of public good provision induces redistributive tensions within the federation, with significant empirical and theoretical implications for our understanding of federal politics. Our key technical results characterize and provide sufficient conditions for the existence of a voting equilibrium with two levels of public good provision. Substantively, we show that the presence of spillovers in dual-provision federations results in political conflicts between the region-members of the federation and between the federal and the regional levels of government. These conflicts manifest themselves in regions' attempting to increase or decrease the role of the federal government, relative to the regional governments, in order to force other regional governments into making particular political and economic choices.[1] We show that

[1]In explaining the rivalry between the federal and some of the regional governments, this mech-

these attempts (1) may help account for the otherwise puzzling patterns in state support for federal programs, akin to the "red states/blue states paradox" (Lacy 2002); (2) may give rise to politically potent ends-against-the-middle majority coalitions that often elude directly political explanations; and (3) lead to conflicts over the choices of institutional structures organizing the decision-making in federations, though not necessarily to the instability of collective institutional choice.

Our model of federations could be seen as combining some of the key elements of two approaches to analyzing the political economy of federations, which have been the focus of the existing analyses and which may be referred to as the "scale" and the "spillover" mechanisms.[2] The first of these, requiring more explicit cooperation among members, posits federal structures as outcomes of the economies of scale, which make it profitable for states to join forces in the selection of policy because the returns to joint economic action exceed the sum of the returns to the independent actions by the members. Examples of models that explore this mechanism of union-formation include Casella (1992) and Alesina and Spolaore (1997), which focus on the scale effects of trade and Persson and Tabellini (1996a and b), which draws on the scale effects of risk sharing. Difficulties in enforcing agreements on which such unions are based are considered in Bednar (2001) and De Figuiredo and Weingast (2001).

The second political-economic mechanism prominent in the extant work focuses on the possibility of members enjoying spillovers in the provision of local and federal public goods in the federation. Less explicitly cooperative than the first mechanism, the spillover mechanism more immediately lends itself to the analysis of the distributive properties of policy-making in federations, which are, arguably, the central source of tension in this conception of federalism. Papers exploring various

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anism complements the credit claiming incentives that are highlighted in Bednar (2004), though it does suggest that, unlike in the case of credit-claiming, we should not expect this rivalry to be uniform across regions.

[2] Well-known surveys of economic mechanisms underlying federal systems, albeit focusing on other criteria, include Alesina, Perotti and Spolaore (1995), and Bolton, Roland and Spolaore (1996).

elements of this mechanism include Cremer and Palfrey (2002), who analyze the distributive effects of unfunded federal mandates, and Alesina et al. (2003), who consider the possibility of supplementing local provision at the federal level (see below). Unlike in the Alesina et al. model, the presence of income heterogeneity plays a central role in our causal account of distributive effects of federal politics. Rather than assuming primitive differences in regional demands for public good, we induce these differences endogenously from the interaction between the relevant spillover factors and the differences in regional incomes, which enables us to develop predictions in terms of these empirically obervable regional characteristics.[3]

Although they do not figure in our model, factors such as the possibility of unwanted federal programs, credit-claiming behavior, the geographic variation in the degree of interdependence among the state-members of the federation, etc. are also, no doubt, important contributors to the explanation of the workings of federal systems and of the empirical phenomena, such as "the red states/blue states paradox," that characterize them. In excluding these factors, our model should not be taken to imply that the causal mechanism we delineate is solely responsible for such phenomena, only that the elements of federal systems we isolate may - via the mechanism we analyze - be in an of themselves important contributing factors to their explanation. In this sense, the model we provide is useful precisely because it focuses on one particular causal mechanism, making clear its workings, its political effects, and the conditions under which it is operative. Other elements of federal systems may, without negating the mechanism we analyze, yield both complementary and opposing causal mechanisms. The weights that should be assigned to these mechanisms in explaining particular empirical phenomena cannot be determined without a systematic empirical investigation, which must be guided by the relationships between factors that are identified in these mechanisms. From this standpoint, and given the nascent state of the theoretical analysis of fed-

[3]Our basic setup is closest to Epple and Romano's (2003) model of collective public good provision with supplemental voluntary provision, which could be re-interpreted as a model of federation in which the federal and local means of provision are identical and in which the public good is a pure one.

eralism, we are in the beginning stages of an important research agenda, and our model should be thought of as a contribution to them.

The remainder of the paper is organized as follows. In the first section to follow we present our results on the existence and the properties of the equilibrium in federations with joint provision. The next section addresses the issues of constitutional variation, including the comparative institutional analysis of political (de-)centralization. It is followed by a brief discussion section and an appendix that gathers the proofs of all formal propositions in the paper.

The Model

Notation and Primitives

The sequence of the game is as follows. First, the citizens of the federal union choose their federally provided level of public good. Then, citizens of each region comprising the union, simultaneously choose their respective regional levels of provision. Both levels of decisions are made by majority rule of the respective jurisdiction. Following the realization of the federal and the regional provision levels, citizens of the union consume their public and private goods.[4]

There are n regions in the union, where n is odd,[5] and l members of the federation engaging in supplemental local provision. The corresponding sets of member regions are denoted as N and L respectively, with $L \subseteq N$. In the interests of tractability, all regions are assumed to have equal populations.[6]

[4]We comment on the possibility of reversing the order of provision in the following section.

[5]The results extend to n even in the usual fashion without complications.

[6]The mobility of voters across regions is beyond the scope of the present paper and is left to the future work extending the model developed here. Not modeling it explicitly here has the advantage of allowing us to evaluate the independent impact of spillovers on federal political economy, as well as to compare our results to the results in other papers that model federal system with spillovers and which at the moment do not allow for voter mobility.

Let u_j be the utility of the median agent in region j. We assume generalized Cobb-Douglas preferences

$$u_j(x_j, y_j) = x_j^a y_j^b, \tag{1}$$

where y_j is the amount of public good enjoyed by j and x_j is j's private good. The assumed functional form treats public and private goods as essential in some measure and as complements, e.g. as complementary inputs to the productive economic activities of individual agents. Consequently, the agent requires positive amounts of both goods, and the marginal productivity of each input is increasing in the presence of greater amounts of the other. In many cases of public good provision, especially those of large-scale legal, physical, and financial infrastructure, this assumption is particularly plausible and warrants considerable attention in the analysis of political economy of federal unions.

Additionally, we use the following notation to denote the corresponding income variables: H is the vector of regional incomes, with H_j as the total income of a generic region j and H_m the total income in the median region of the income distribution. Let H^T be the total income of the federation, and h_j the income of the median agent in region j. Given our focus on the political tensions *between* regions, we treat the median voter in a region as the relevant decision-maker for that region, and hence it will be convenient to designate both a region and its median voter by the same subscript.

We assume that the private good is numeraire, i.e., the "monetary unit." Producing a unit of public good for region j in region j costs one unit of private good. Let $s_L < 1$ be externalities from public goods produced in other localities, measured as the proportion of those goods that are enjoyed by another region. s_F is the benefits derived from federally provided public goods, measured as a proportion of the goods enjoyed. Although, in the interests of brevity, we focus our interpretation of the model on the effects of positive externalities, it is fully consistent with the presence of negative externalities as well. In the latter case, the rationale for the the existence of the federal government may be thought to be the alleviation of such externalities, which is analytically equivalent to the production of positive ones.[7]

The federal-level policy we analyze imposes a uniform tax rate and provides equal amounts of the public good to all regions in a way that may constitute a different means (technology) of producing the public good. Our assumptions here are flexible enough to cover the previously unexplored and both theoretically and empirically important cases in which federal provision may exploit economies of scale in production, as well as the case in which federal provision is equivalent to the equal division of federal revenues among the member regions, who then produce the public good locally just as they would using locally raised revenue (Alesina et al. 2003).

The federal tax rate is t^F and the vector of local tax rates is $t = (t_1, t_2, ..., t_{j,} .., t_n)$, with the understanding that $t_j, t^F \in [0, 1]$. The government faces a balanced budget constraint, so all revenue is invested in public goods at the corresponding level of government. Thus,

$$\begin{aligned} y_j &= t^F H^T s_F + t_j H_j + s_L \sum_{k \in L \setminus j} t_k H_k \\ x_j &= h_j(1 - t^F - t_j) \end{aligned} \tag{2}$$

We interpret s_F to reflect both the direct impact (from the federal provision for own region) and the indirect impact (via cross-regional spillovers from the federal provision for other regions). Note that s_L and s_F can be treated as rates of substitution of own regions' locally provided public good for other regions or federal public goods.

[7]Suppose that regions produce negative externalities in the form of pollution and that the federal government creates an abatement program to eliminate them. Then the federal government may be thought to be producing a public good, in the form of cleaner air or water, or equivalently it may be thought to be eliminating a negative externality (pollution). If the government action constitutes an actual restriction on some beneficial activity that creates a negative externality as a by-product, then the assumption $y_j \geq 0$ implies that (1) the *net* benefit of government actions is positive, so that adequate benefits are always provided to compensate for losses, and (2) government abatement programs prevent firms from increasing their rate of pollution in response to government efforts.

The Politico-Economic Equilibrium

Our solution concept is subgame-perfect Nash Equilibrium in undominated strategies. More specifically, the equilibrium is characterized as the pair (t^{F*}, t^*), such that the federal tax rate t^{F*} is chosen by majority rule, every voter votes for her preferred tax rate in any pair-wise contest, and, for all j,

$$t_j^*(t_{-j}, t^F; s_F, s_L, H, a, b) = \arg\max u_j(t_j, t_{-j}, t^F; .).$$

Solving by backward induction, we find the preferred regional tax rate of the median voter in region j, t_j, given her expectations of the other regions' simultaneously chosen tax rates, t_{-j}, and the known federal tax rate t^F. Substituting (2) into (1) yields

$$u_j(t^F, t, .) = ((1 - t^F - t_j)h_j)^a (t^F H^T s_F + t_j H_j + s_L \sum_{k \in N \backslash j} t_k H_k)^b \tag{3}$$

To locate any interior solution, we obtain the Kuhn-Tucker conditions, which (after reducing and simplifying) yield:

$$t_j = \begin{cases} \frac{1}{a+b} \left[b(1 - t^F) - a(t^F \frac{H^T}{H_j} s_F + s_L \sum_{k \in N \backslash j} t_k \frac{H_k}{H_j}) \right] \\ \qquad \text{if } b(1 - t^F) > a(t^F \frac{H^T}{H_j} s_F + s_L \sum_{k \in N \backslash j} t_k \frac{H_k}{H_j}) \\ 0 \qquad \text{otherwise} \end{cases} \tag{4}$$

Because regions have identical marginal rates of substitution between private and public goods and the tax is a flat rate on endowment, the domestic politics within regions (i.e., the politics of the determination of the supplemental levels of public good), is essentially trivial: holding constant the federal tax t^F, agents within regions have identical preferences over internal taxation levels financing the supplemental provision of the public good. Thus the choice of regional tax rate depends on the region's total income, H_j, but does not otherwise depend on the median voter's income, h_j. The simplicity of the intra-regional politics helps place the inter-regional politics in the spotlight, and will make it easier to see the causes and consequences of the disagreements between regions over federal taxation and provision. These disputes will turn on the combination of the redistributive pressures present in an heterogenous-income distribution and the possibility of free-riding implicit in inter-regional spillovers. We begin our analysis of these effects with the following lemma, which is instrumental in proving the main results of the model:

Lemma 1 *In any equilibrium, for any pair of regions j and k such that $H_j < H_k$, if region j provides a positive amount of the public good at the local level, then region k provides a strictly greater amount.*

Proof See Appendix. ■

Let $L(t^F)$ be the set of members which engage in supplemental local production, i.e., for which $t_j > 0$. Let $|L(t^F)| = l$. If we index the regions from richest to poorest, i.e., so that $H_1 \geq H_2 \geq ... \geq H_l \geq ... \geq H_n$, the key consequence of this lemma for the present model is that l must be the highest integer s.t. $t_l H_l > 0$, i.e., it has to be such that both $t_l H_l > 0$ and $t_{l+1} H_{l+1} = 0$ (where the lower bound on tax rate may be binding). Hence, $\sum_{j \in N} t_j H_j = \sum_{j \in L} t_j H_j$, and from (4) we can write

$$\sum_{j \in N} t_j H_j = \sum_{j \in L} t_j H_j = \frac{1}{a + b + as_L(l-1)} (b(1-t^F) \sum_{k \in L} H_k - as_F t^F H^T l). \tag{5}$$

Substituting (5) into (4) and solving for $t_j H_j$ where $t_j > 0$, we get:

$$\begin{aligned} t_j^* H_j &= \frac{b}{a + b - as_L}(1-t^F) H_j \\ &\quad - \frac{1}{a + b + as_L(l-1)} (as_F t^F H^T + \frac{abs_L}{a + b - as_L}(1-t^F) \sum_{k \in L} H_k), \end{aligned} \tag{6}$$

where, from the above ordering of H_j and (6), l and $L(t^F)$ are formally defined by the following system of inequalities:

$$\begin{cases} (a + b + as_L(l-1)) b(1-t^F) H_l > abs_L(1-t^F) \sum_{k \in L} H_k + (a + b - as_L) as_F t^F H^T \\ (a + b + as_L(l-1)) b(1-t^F) H_{l+1} \leq abs_L(1-t^F) \sum_{k \in L} H_k + (a + b - as_L) as_F t^F H^T \end{cases} \tag{7}$$

Together (6) and (7) determine the Nash equilibrium in the simultaneous-move local provision game.

Lemma 2 *For each federal tax rate t^F, there is a unique group of regions, $L(t^F)$, that are local providers at that tax rate.*

Proof See Appendix. ■

By Lemma 1, this group of regions must include the wealthiest $l(t^F)$ regions in the federation. Given this solution to the subgame, we proceed to determining the agents' preferences over federal tax rates. These preferences depend critically on the relative merits, from an individual's point of view, of the federal and the local means of provision, taking into account the strategic responses of other regions to changes in each.

Let $l_{\max} = |L(0)|$ be the number of regions that engage in local provision when there is no federal provision of the public good, i.e. such that

$$H_{l_{\max}} > \frac{as_L}{a+b+as_L(l_{\max}-1)}\left(\sum_1^{l_{\max}} H_k\right) \geq H_{l_{\max}+1}$$

The conjunction of Lemmas 1 and 2 implies that the range of t^F can be partitioned into $[0, \hat{t}^F_{l\max})$, $[\hat{t}^F_{l\max}, \hat{t}^F_{l\max-1}), ..., [\hat{t}^F_1, 1]$, so that each of these intervals defines a range of t^F, corresponding to a unique L. These intervals are bounded by the federal tax rates, $\hat{t}^F_j$ (not necessarily optimal, from region j's standpoint), at which an additional region j ceases local provision, i.e., at which $t^*_j(\hat{t}^F_j) = 0$. Substituting $t^*_j = 0$ and $l = j$ into (6) and solving for $t^F (\equiv \hat{t}^F_j)$, we obtain

$$\hat{t}^F_j = \frac{(a+b+as_L(j-1))H_j - as_L\sum_1^j H_k}{(a+b+as_L(j-1))H_j + (a+b-as_L)\frac{a}{b}s_F H^T - as_L\sum_1^j H_k}, \tag{8}$$

which $\forall j \leq l_{\max}$ is greater than 0. Then, for $t^F < \hat{t}^F_j$ and $t_j \in [0, t^*_j(\hat{t}^F_j, .))$, j wishes to procure more public good through some form of increased taxation.

Given this partition of the policy space, we proceed by identifying the extrema on each interval. Because 0 is a binding lower bound on local tax rates, the expression for j's indirect utility as a function of federal tax rate, given the equilibrium behavior in the local provision game, is different when j engages in local provision and when j does not.

Since, in the presence of spillovers, there may exist multiple local optima, regions' preferences are neither necessarily single-peaked nor necessarily order-restricted. Although this means that we cannot rely on standard theorems for aggregating the preferences over t^F, the next two propositions provide sufficient conditions for the existence of a unique stable outcome of majority rule and characterize that outcome. These restrictions on the preference profile of the federation are expressed in terms of two functions $f(j; a, b, s_L, s_F, H)$ and $g(j; a, b, s_L, s_F, H)$, such that the sign of $f(.)$ determines whether the jth region's utility is increasing in the federal tax rate at a federal tax rate of 0, and the sign of $g(.)$ whether the jth region's utility is decreasing in the federal tax rate at the rate at which it ceases to provide locally, $\hat{t}^F_j$. We characterize both functions explicitly in the Appendix and discuss their responsiveness to changes in parameter values later in this section of the paper. Recalling now that j indexes regions in the descending order of their income, we can formulate the following result:

Proposition 1 *There exists a known function $f(j; a, b, s_L, s_F, H)$, such that if $f(1; .) > 0$, then:*

(1) all regions that engage in local provision at t^F strictly prefer a higher tax rate, and each region's most-preferred tax rate is one at which it does not engage in local provision;

(2) for any two regions $j, k \in N$ such that $H_j < H_k$, the most-preferred federal tax rate of j is no greater than that of k, i.e. $t^{F*}_j(t^*, .) \leq t^{F*}_k(t^*, .)$;

(3) there exists a Condorcet winner t^{F*}, which coincides with the most-preferred federal tax rate of the median voter, i.e., $t^{F*} = t^{F*}_m$;

(4) the m poorest regions, comprising the majority of member regions of the federation, do not engage in local provision at the equilibrium federal tax rate.

Proof See Appendix. ■

Proposition 1 characterizes one set of strategic incentives faced by regions heterogeneous in income in a federal systems with two levels of public good provision. Under the specified conditions, a majority of federation members select a low federal tax rate, anticipating that a minority of wealthier members will provide additional amounts of the public good. Because members enjoy positive externalities from public goods provided by other regions, free-riding on the wealthier members at a lower level of provision is sometimes more attractive for the majority than a more efficient level of provision that entails paying a higher federal tax.

The properties of the equilibrium characterized in Proposition 1 are consistent with the seemingly puzzling fact ("the red states/blue states paradox") that in the United States (poorer) federal units that would seem to benefit most from the redistributive federal programs often oppose the expansion of federal government. Consistent with this observation, Lacy (2002, p.2) notes in his analysis of the differences in support for the incumbent party presidential candidate in the "red" (net federal payer) and the "blue" (net federal recipient) states in the US:

> It would make sense that the states that lose money to the federal government would be more likely to vote for the candidate who promised to cut taxes and reduce the scope of government, and that the states that gain from the federal government would support the candidate who would protect or increase federal spending. The evidence shows that such a story is exactly backwards. In a curious paradox ... Bush won most of the states that benefit from federal spending, while Gore won most of the states that bankroll the federal government. Perhaps more interesting, the states in which Al Gore did worse than Bill Clinton did in 1996 are the states that increased their net take from the federal government in the two years leading up to the 2000 election.

The Proposition 1 suggests that when its antecedent condition holds, these observations need not be paradoxical. When the public goods are substitutes, the presence of across-states externalities may make it so that the net receipt of federal funds to finance the public good provision, coming at some non-zero price, is in the end worse for some states than free-riding on the spillovers from the public good provision in other states. The poorer (and hence, net federal financing recipient) regions/states object to the increases in federal provision, whereas the wealthier (and hence, net federal taxpayer) regions/states prefer relatively higher levels of federal provision. If so, then, the states may be expected to respond precisely as they did in the 2000 elections.[8]

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[8]Another explanation for this behavioral pattern could be differences in the demand for public

We next provide another sufficient condition for the existence of the Condorcet winner, under which $t_j^{F*}(t^*, .)$ is weakly non-monotonic.

Proposition 2 *There exist known functions $g(j; a, b, s_L, s_F, H)$ and $f(j; a, b, s_L, s_F, H)$, such that if, for some $\hat{l} \leq l_{\max}$, $g(j; .) < 0$ for every $j \leq \hat{l}$, and $f(\hat{l}+1; .) > 0$ if $\hat{l} < l_{\max}$, then:*

(1) the wealthiest $\hat{l}$ regions strictly prefer to decrease t^F, and have a most-preferred federal tax rate of 0; and every other region that engages in local provision at t^F strictly prefers to increase it, and its most-preferred tax rate is one at which it does not engage in local provision;

(2) most-preferred federal tax rate is weakly non-monotonic in income, with middle income regions preferring higher tax rates than do wealthier and poorer regions;

(3) a unique Condorcet winner t^{F*} exists and is (a) 0 if $m \leq \hat{l}$, or (b) $t^{F*}_{m+\hat{l}}$ if $m > \hat{l}$;

(4) the wealthiest $\hat{l}$ regions engage in local provision at the equilibrium federal tax rate t^{F*}.

Proof See Appendix. ■

The preference profiles that satisfy this condition may give rise to majority coalitions with very different compositions. While some profiles result in an equilibrium in which the voters are divided by income, i.e. the rich, who favor no federal provision, versus the poor, others produce an equilibrium in which the richest and poorest regions ally against the middle-income regions. In such cases, the rich and the very poor prefer little or no federal provision, and the middle-income regions champion higher federal tax rates. To be sure, the rich and the poor favor low taxes for different reasons. The rich oppose the redistributive effects of federal provision. The poor are, in

good induced by the differences in production technologies across states, but such differences (not modeled in this paper) are likely to work in the direction opposite from that which would be necessary for the explanation. It is unlikely that poorer states, with, among other things, worse economic infrastructures, have a lower need for the public good component in their production technologies. This conclusion notwithstanding, the red states/blue states "paradox" may, of course, be overdetermined by other causal antecedents, such as the military base closings, etc., as well. Our point here is only that the data pattern it represents is consistent with the causal mechanism we expect to be widely operative in federal structures.

such profiles, so poor relative to the rich, and obtain so much public good from the local provision of other regions (in the total absence of federal provision), that their demand for additional private good is greater than their demand for additional public good.

This "ends-against-the-middle" result is the opposite of that of Epple and Romano (2003), in which the rich and poor desire higher taxation than do the middle-income voters. Because in their paper, the public good is assumed to be truly global, every agent prefers additional federal provision to her own voluntary (local) provision of the good, since she bears under the former scheme only a fraction of the cost that she bears under the latter, while enjoying access to the same amount of the public good. Hence, in their model, the richest agents always demand high levels of federal taxation. Lower-income agents may demand higher levels of federal provision than middle-income agents, however, producing a coalition of rich and poor in support of higher taxation. By contrast, in the present paper, because the quantity of public good that an agent enjoys depends not only on the resources allocated to its production, but also the location of its production in the federal system, wealthy regions may experience a decrease in the amount of public good that they enjoy as federal taxation increases. It is also the case that different regions engaging in local provision enjoy different amounts of the public good, giving rise to the possibility that, while some may be harmed by increases in federal provision, other local providers benefit from it. Thus middle-income regions may prefer higher levels of federal provision than do the rich and the poor.

<u>The Induced Preferences Over Federal Tax Rates: the Intuitive Characterization</u>

Figure 1 depicts the indirect utilities $u(t^F, t^*(t^F))$ over federal tax rates for the members of a federation with $|N| = 5$ when the antecedent condition of Proposition 2 holds. Regions 1 and 2, which are the wealthiest members, have strictly decreasing utility. Both 1 and 2 engage in local provision at Region 3's most-preferred federal tax rate, t_3^{F*}. Regions that do not engage in local provision over a given interval of federal tax rates share the same preferences over those tax rates, e.g. regions 1, 2, and 3 all have a maximum at t_3^{F*}, and 1 and 2 both have a higher maximum at t_2^{F*}, indicating that they both prefer t_2^{F*} to t_3^{F*}. Region 3 does not have a maximum at t_2^{F*} because it engages in local provision at that tax rate, $t_2^{F*} < \hat{t}_3^F \leq t_3^{F*}$. Because regions not engaging in local provision over a given interval of federal tax rates have the same preferences, and because poorer regions stop providing locally at lower tax rates than do richer regions, a poorer region may prefer a lower tax rate than does a richer region, but it will never prefer a higher one. For this reason, most-preferred tax rates are weakly increasing in income among all regions that strictly prefer higher tax rates when they are local providers (i.e. all local providers under the conditions of Proposition 1, and $\{\hat{l}+1, ..., l_{\max}\}$ under the conditions of Proposition 2).

Regions that do engage in local provision over a given interval of federal tax rates do not necessarily share the same preferences over those tax rates, however. Although Regions 1, 2, and 3 all engage in local provision on $[0, \hat{t}_3^F)$, 3 prefers higher tax rates on this interval, whereas 1 and 2 prefer lower tax rates. This difference is a result of the unequal distribution of wealth and the fact that different local providers enjoy different amounts of public good, insofar as they obtain greater benefit from public goods produced in their own districts ($s_L < 1$).

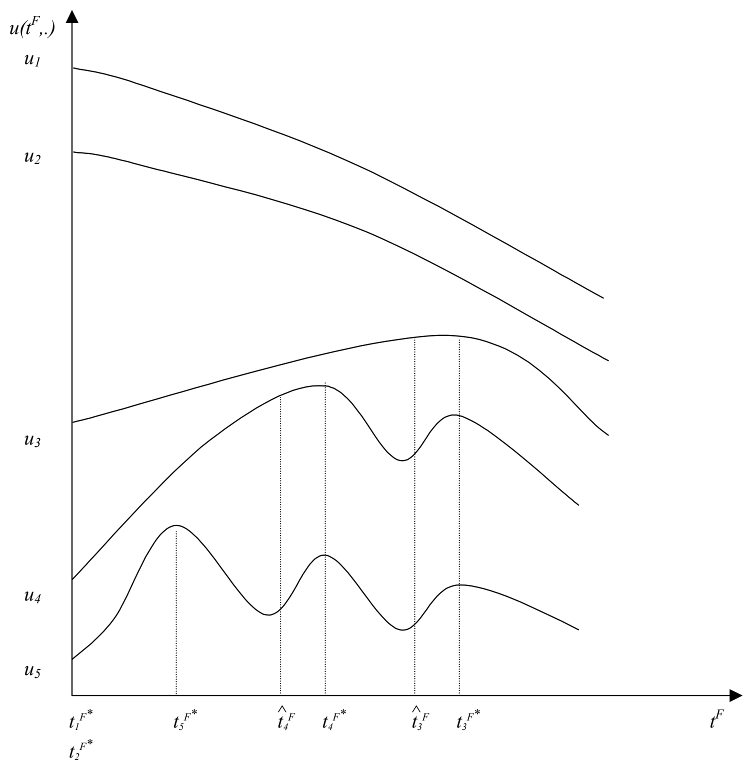

Figure 1: Induced Preferences Over Federal Tax Rates Satisfying Conditions of Proposition 3

The conditions guaranteeing the existence of a voting equilibrium in Propositions 1 and 2 are closely related. In each case, it is necessary that the utility of the median voter in every region that engages in local provision have monotonic preferences on the interval of federal tax rates for which it engages in local provision, $[0, \hat{t}_j^F]$, i.e., each must either strictly prefer higher taxation or lower taxation over those tax rates for which it is a local provider. The direct effect of increasing the federal tax rate on the amount of public good j enjoys is positive, but it is offset by all local providers' reducing their local provision in response. While the marginal increase in federal provision is constant, the marginal decrease in local provision grows smaller as fewer regions engage in local provision, since regions who have ceased local provision entirely cannot reduce their local provision further in response to increases in federal provision. Thus if, for region j, the former effect dominates the latter effect for some number of local providers, then it does so for fewer local providers as well. Therefore to insure that a local provider j's consumption is strictly increasing in federal tax rate (for as long as they are a local provider), it is sufficient to insure that it is increasing on $[0, \hat{t}_{l_{\max}}^F)$, as in Proposition 1. Similarly, to insure that consumption is strictly decreasing in federal tax rate, it is sufficient to insure that it is decreasing on $[\hat{t}_{j+1}^F, \hat{t}_j^F)$, as in Proposition 2.

Because a richer region pays more than a poorer one for a given increase in federal provision, the richer region reduces its local provision more quickly than does the poorer one as the federal tax rate increases. Thus the amount of public good enjoyed, and hence consumption, decreases more quickly or increases more slowly for a richer region. It follows that, given two local providers for whom consumption is decreasing at $t^F = 0$, the poorer region's consumption will reach its minimum at a lower federal tax rate. Thus if the richest region's consumption is increasing on $[0, \hat{t}_{l_{\max}}^F)$, as required in Proposition 1, then all poorer local providers must also have increasing consumption on $[0, \hat{t}_{l_{\max}}^F)$. To insure that consumption is strictly decreasing on $[0, \hat{t}_j^F]$, as for the $\hat{l}$ richest regions in Proposition 2, it is sufficient to require that the poorest such region providing locally at t^F has decreasing consumption. Because poorer regions stop providing locally before richer regions, as established in Lemma 1, this requirement is equivalent to the statement in Proposition 2.

Evaluating Sufficiency Conditions

To understand the weight of the sufficient conditions in Propositions 1 and 2, note first that the number of regions that provide the public good locally in the absence of federal provision, $l_{\max}$, is independent of the benefits of federal provision, s_F. Given this independence, it is evident that $\frac{\partial f}{\partial s_F} > 0$ and $\frac{\partial g}{\partial s_F} > 0$. Consequently, the antecedent of Proposition 1 is more easily and the antecedent of Proposition 2 less easily, satisfied as s_F increases.

To get some intuition about the nature of the economic phenomenon expressed by the two spillover coefficients, consider expressing s_F in terms of s_L. Consistent with our assumption that federal provision directs equal units of public good to all districts, region j's share of federal provision can be written as $s_F t^F H^T = \gamma(\frac{1}{n} t^F H^T + s_L \frac{n-1}{n} t^F H^T)$, where γ is a measure of the relative efficiency of federal provision. Simplifying, we get $s_F = \gamma \frac{(1+s_L(n-1))}{n}$. If $\gamma < 1$, then the federal means of provision is inherently less efficient than the local means of provision, and if $\gamma > 1$ then federal provision is more efficient[9]. Table 1 below shows the values of γ that correspond to different values of the spillover coefficients s_L and s_F. A line is drawn demarcating the cases in which the federal means of production is more efficient, corresponding roughly to the upper-right portion of the table, and cases in which the local means is more efficient.

Because the number of regions engaging in local provision in equilibrium at any given tax rate is defined implicitly by a system of inequalities, it is difficult to obtain comparative statics for $f(j, a, b, s_L, s_F, H)$ and $g(j, a, b, s_L, s_F, H)$ analytically for most parameters of the model, and so here we report results of numerical estimations of the determinants of sustaining the existence results in Propositions 1 and 2. For a particular set of parameter values ($a = 0.6$, $b = 0.4$, $H = (100, 90, 80, 70, 50)$) we estimate $l_{\max}$, represented here by superscripts, and the values of $f(j, a, b, s_L, s_F, H)$ and $g(j, a, b, s_L, s_F, H)$. The bold-faced cells to the left of the $s_F = .5$ column correspond to cases in which Proposition 2 holds, and the bold-faced values in the cells to the right

[9]Note that whether or not $\gamma > 1$ is distinct from the question of whether membership in the federation is attractive, in part because the existence of spillovers may make it attractive even if $\gamma < 1$.

of it to cases in which Proposition 1 holds.

$s_L \backslash s_F$	.1	.3	.5	.7	.9	1.1	1.3	1.5	1.7
.1	**.36**^{5}	1.09^5	1.79^5	2.50^5	3.21^5	3.93^5	**4.64**^{5}	**5.36**^{5}	**6.07**^{5}
.3	**.23**^{5}	.68^5	1.14^5	3.25^5	2.05^5	2.50^5	**2.96**^{5}	**3.41**^{5}	**3.86**^{5}
.5	**.17**^{4}	.50^4	.83^4	1.17^4	1.50^4	**1.83**^{4}	**2.17**^{4}	**2.50**^{4}	**2.83**^{4}
.7	**.13**^{4}	.40^4	.66^4	.92^4	1.18^4	**1.45**^{4}	**1.71**^{4}	**1.97**^{4}	**2.24**^{4}
.9	**.11**^{3}	.33^3	.54^3	.76^3	**.98**^{3}	**1.20**^{3}	**1.41**^{3}	**1.63**^{3}	**1.85**^{3}

Table 1: Simulation of Sufficient Conditions for Federal Tax Equilibria

We might expect, absent strategic and redistributive effects, that members would prefer federal provision when it is more efficient, i.e. when $\gamma > 1$, and local provision when it is more efficient, i.e. when $\gamma < 1$. The redistributive features of federal provision and the voluntary nature of local provision complicate the effect of relative technological efficiency on induced preferences in equilibrium. Because a condition of federal provision is that each region enjoy equal amounts of the federally-provided good, and because the regions have unequal wealth, federal provision is redistributive, dampening the richest region's enthusiasm for that means of provision. Redistribution, however, does not explain a second interesting feature of the results: satisfaction of the antecedent of Proposition 1 is non-monotonic in γ. For example, although it is satisfied for $\{s_L = .9,\ s_F = .7,\ \gamma = .76\}$ and $\{s_L = .9,\ s_F = .9,\ \gamma = .98\}$, it is not satisfied for $\{s_L = .7,\ s_F = .7,\ \gamma = .92\}$ or for $\{s_L = .5,\ s_F = .5,\ \gamma = .83\}$. Similarly, it is satisfied for $\{s_L = .5,\ s_F = 1.5,\ \gamma = 2.50\}$, but not satisfied $\{s_L = .3,\ s_F = 1.1,\ \gamma = 2.50\}$.

This non-monotonicity is the result of the voluntary nature of local provision and the strategic response of regions' local provision choices to increases in federal provision. While each local provider may benefit directly from switching to federal provision because it is technologically more efficient– sufficiently more efficient to compensate for redistributive effects– it suffers indirectly from other regions' reducing local provision in response to the increase in federal provision. The condition $f(1, a, b, s_L, s_F, H) > 0$ is satisfied only if the former effect is greater than the latter.

Not all regions are necessarily able to reduce their provision of the public good in response to federal provision, however. When spillovers from local provision are sufficiently large, the poorest regions will not engage in local provision even in the total absence of federal provision, because they consume enough of the public good locally provided in other regions. It follows, then, that they will not be able to respond to increases in federal provision, and thus the net effect of increasing federal taxation on the utility of the richer regions will be greater than it would be if all regions were initially engaged in local provision. For this reason, richer regions find federal provision more appealing when, ceteris paribus, fewer regions are engaging in local provision, and, as the entries in Table 1 show, the antecedent condition of Proposition 1 is more likely to be satisfied, for a given value of γ, when $l_{\max}$ is lower.

Given that redistribution is inherent in federal provision, and given the dependency of the above results on the number of regions that engage in voluntary provision, the satisfaction of the existence conditions also depends on the dispersion of the distribution of regional income. The antecedent of Proposition 2 is more easily satisfied for more dispersed income distributions. The satisfaction of the antecedent condition of Proposition 1 is non-monotonic in the dispersion of the income distribution, however. It is satisfied for sufficiently egalitarian distributions of income because there is little redistribution and little difference in the behavior of the regions in such cases. It is also satisfied for sufficiently inegalitarian distributions, because in such cases the poorer regions do not engage in local provision at any federal tax rate. For intermediate levels of dispersion in the income distribution, the condition is not satisfied because the poorer regions' reduction in levels of local provision outweighs the additional direct benefits to the richer regions of federal provision, as discussed above. The effects of increasing the dispersion of the distribution are the same whether the median is less than the mean or vice versa.

The Effects of Spillovers

To determine the effect of introducing positive spillovers into the model of federations with two levels of public good provision, we next provide the properties of the equilibrium in the federation when $s_L = 0$:

Proposition 3 *In the federation without inter-regional spillovers:*

(1) if $s_F > \frac{H_m}{H^T}$*, then* $t^{F*} = \frac{b}{a+b}$ *and the median and all poorer regions choose* $t_j = 0$*;*

(2) if $s_F < \frac{H_m}{H^T}$*, then* $t^{F*} = 0$ *and all regions* j *choose* $t_j = \frac{b}{a+b}$*.*

Proof See Appendix. ■

In the federation without inter-regional spillovers, if $s_F > \frac{H_1}{H^T}$, then all regions prefer pure federal provision, i.e., $t^F = \frac{b}{a+b}$ and $t_j = 0$, for all $j \in N$; if $s_F < \frac{H_n}{H^T}$, then all regions prefer pure local provision, i.e., $t^F = 0$ and $t_j = \frac{b}{a+b}$, for all $j \in N$. The inter-regional disagreement occurs when the efficiency of federal provision is in the middle-range, i.e., when $s_F \in (\frac{H_n}{H^T}, \frac{H_1}{H^T})$. In that case, some regions prefer federal and others pure local provision. Since within each region voters share induced preferences over t^F, the outcome of majority rule in the federation as a whole is identical to the outcome of weighted voting among member states, where weights are proportional to states' populations. Moreover, since, by assumption, all regions have equal populations, we can, in this and the subsequent results, restrict our attention to simple majority rule among regions. Because the regional preferences are single-peaked, the Condorcet winner always exists, and the prediction is straightforward.

We can now ascertain the direct effects of the existence of spillovers in a federal system with joint federal and local provision, by comparing the results of Proposition 3 with those in the model with positive local (inter-regional) spillovers. The following proposition summarizes the salient features of this comparison:

Proposition 4 *(1) If* $s_F < \frac{H_m}{H^T}$*, the presence of local spillovers lowers local provision in the median and the richer regions, leaving constant the majority's preferences over federal provision.*

(2) If $s_F > \frac{H_m}{H^T}$*, the presence of local spillovers (weakly) lowers federal provision, leaves local provision unchanged for the majority of regions, and (weakly) increases local provision for a minority consisting of the richest regions.*

Proof See Appendix. ■

In the absence of any spillovers from local provision, i.e. for $s_L = 0$, each region's most-preferred federal tax rate is 0 or $\frac{b}{a+b}$, and if it is 0 when $s_L = 0$, then it is also 0 when $s_L > 0$. Thus, if, with

$s_L > 0$, the majority-chosen tax rate t^{F*} is on the interval $(0, \frac{b}{a+b})$, then the majority of members are free-riding on spillovers from other regions' local provision. Since local provision is monotone increasing in regional income, it is the poorer regions who are free-riding on the local provision of richer regions whenever $t^{F*} < t_1^{F*} \leq \frac{b}{a+b}$.

Part 1 of Proposition 4 suggests that under joint federal and local provision, the presence of local spillovers has a substitution effect similar to that which Crémer and Palfrey (2002) characterize under the system of unfunded federal mandates. Part 2 suggests, however, the presence of another kind of substitution effect that has very different distributive properties. Whereas the use of federal mandates favors the rich regions over the poorer regions by allowing the former to enjoy the spillover effects from forcing high levels of local provision in the poorer regions, our analysis implies that the poorer regions may use the policy tools offered by joint federal and local provision to "free ride" on local provision in the richer regions by shifting the burden of provision toward them and away from themselves. Note that when the condition that ensures that t_j^{F*} is increasing in j's income is violated, either the free-riding by the poorer regions persists (whenever t_j^{F*} is increasing in j's income) or the rich regions' preferred federal tax rate is 0 and weakly below that preferred by the poorer regions. In the latter case, the distributive effects of joint provision once again favor the poorer regions, but through a more familiar directly redistributive causal mechanism.

Constitutional Variation

Subsidiarity and the Order of Provision

It may be beneficial to consider how the predictions of the game considered in the previous section would differ if we reversed the order of provision, so that regions, rather than the federal level, became the Stackelberg leaders. Assuming that sequence, it is clear that when the wealthy regions prefer a federal tax rate above that which would be preferred by the pivotal voter, they would now have an incentive to commit to lower levels of regional provision, in expectation of the subgame-perfect behavior in the federal provision subgame. This scenario strikes us, however, as implausible. Since in federal politics proper, the federal level of provision is considerably more difficult to alter than the local, such strategic "commitments" by local governments are not likely to be viewed as credible. It seems plausible, therefore, that, quite apart from immediate descriptive verisimilitude, a model with the federal level as the Stackelberg leader may, in fact, be a better approximation to the open-horizon repeated sequence of federal and state-level provision decisions than the single such sequence with local levels as the Stackelberg leader.

It is noteworthy in this context that the European Union Charter has an explicit provision of subsidiarity (it is preserved in the constitution of the Union, currently under discussion), which requires that decisions in the Union be made at the lowest level possible. Alesina et al. (2001) interpret subsidiarity to mean that regional provision must precede federal (Union) provision, and use it as the justification for modeling regions as the Stackelberg leaders. Apart from the modeling considerations described in the previous paragraph, this interpretation seems to us to be contestable. If there is federal provision at all, the strict application of subsidiarity would imply that the federal level or a combination of the federal and the regional levels is the lowest level possible for the decision regarding provision. On the other hand, if provision could be either only at the regional level or only at the federal level, or at both levels, then, by subsidiarity, the EU would be required to adopt the first option.[10] We reserve judgment as to whether the case of public good provision we are considering falls into that category, though it bears noting that, since joint federal and local provision is majority preferred to local-only provision (see the following section for details), subsidiarity so construed is unlikely to be a stable institution.

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[10]Even if we view the absolute amounts of regional provision as how much public good, relative to 0, the regions would like to have and so as separable, for the purposes of subsidiarity, from the decision of how much public good they would like to have relative to the regional provision, the fact that the existence of the federal structure is driven here by the existence of federal spillovers seems to limit the force of subsidiarity claim so construed.

Federal (De-)centralization

Suppose that member regions could determine their preferred governance structure, choosing from three forms of government defined by their degree of centralization: reserving the public good provision authority for the national level alone (complete unification), the more decentralized, dual provision, government modeled in our game (federation), and the completely decentralized government with provision issues resolved fully on the relevant local levels (confederation). As the proposition below shows, the regions' preferences will vary with both their economic and political circumstances: regional income and the distribution of preferences in the society.

Proposition 5 *(1) A federation is always majority preferred to confederation and complete centralization. If in the federal system, provision occurs at both levels of government in equilibrium, then this preference is strict.*

(2) If $f(1, a, b, s_L, s_F, H) > 0$, then the majority coalition supporting federation against complete centralization includes the poorest m regions, and the coalition supporting federation against confederation includes the richest m regions.

(3) If for some $\hat{l} \leq l_{\max}$, $g(j, a, b, s_L, s_F, H) < 0$ for every $j \leq \hat{l}$, and $f(\hat{l}+1, a, b, s_L, s_F, H) > 0$ if $\hat{l} < l_{\max}$, then the majority coalition supporting federation against confederation includes the middle-income regions $\{\hat{l}+1, \hat{l}+2, ..., \hat{l}+m\}$, and the coalition supporting federation against complete centralization includes the $\hat{l}$ richest regions and, if those regions alone do not constitute a majority, the $n - (m + \hat{l}) + 1$ poorest regions as well.

Proof See Appendix. ■

This proposition underscores several interesting features of federal politics. First, although institutional preferences vary across regions by income, it is evident that federation is always majority preferred to both completely centralized government and to confederation. Second, the preference of a minority of poor regions for confederation over federation possible under the conditions of part 2 is based on the same rationale that may explain patterns the "red states/blue state paradox" discussed above. Since in confederation, national majorities do not have taxing and spending authority, preference for confederation under these conditions corresponds to implied opposition to federal spending programs even when they are redistributive toward the poor regions.

Third, the existence of the opposition of a minority consisting of the wealthiest regions to the transition from fully-centralized government to federation (which occurs under the conditions of part 2 of Proposition 5 if the they result in different outcomes) is of both substantive and methodological interest. The substantive intuition can be easily conveyed. Under complete centralization, the wealthy regions can insure that their most-preferred federal tax rate of $\frac{b}{a+b}$ is adopted because there is no local provision and so there is no enjoyment of local spillovers to be had. However, with transition to federation, if the median region prefers a lower tax rate, there is a majority supporting it because they can free-ride on the local provision in the wealthy regions. Since the opposition to federalization under such circumstances would come from the wealthiest regions, it seems unwise to discount its political consequences even despite the fact that it would be a minority opposition.

Finally, Proposition 5 offers an interesting comparison of federations with dual provision to federations with local provision subject to federal mandates. Whereas, as Crémer and Palfrey (2002) show, the wealthy regions always prefer federations qua federal mandates to confederations, Proposition 5 shows that their preference for federations qua institutions with dual provision relative to the same baseline is more ambiguous: they may prefer them (under conditions of part 2) or oppose them (under conditions of part 3).[11] To the extent that empirical federations often contain a mix of federal mandates and dual provision, the extent to which stronger federal government advantages wealthier regions is an open issue.

Discussion

Our paper offers an analysis of the political economy of federations with public good provision at both the federal and the regional levels. The key causal mechanism we characterize may be described

[11]Note, interestingly, that although the minority coalition of poorest and wealthiest regions may oppose federation in favor of decentralization, these coalition members will have the opposite preferences over the adoption of federal mandates, with the wealthy regions always supporting and the poor regions always opposing them.

as “inter-jurisdicational free-riding,” with regions exploiting spillover effects by shifting the burden of provision or its costs away from themselves and toward other members of the federation. As our results indicate, the corresponding preferences over federal action may explain otherwise puzzling empirical patterns in regional support for federal spending programs, akin to the “red states/blue states paradox.” More generally, our results may be seen as suggesting that a conservative economic philosophy of preferring both low taxes and low government spending, which may often be observed in poorer states, may have very material underpinnings. In particular, we hypothesize that it may be induced by expectations of indirect economic benefits (through, inter alia, investment and job creation in the state/region) from costly fiscal measures implemented by other states/regions (e.g., upgrading of the infrastructure, job (re-)training programs, etc.). Where we do see poor regions supporting federal spending programs and rich regions opposing them, we should expect the rich (and possibly also the poor) regions to engage in the local provision of substitutes for the federal programs, and by a means of local provision that is not too much less efficient than the means of federal provision (e.g. economies of scale are not too great).

An instructive way of interpreting the causal mechanism that underlies our results is through the prism of the following comparison. Crémer and Palfrey’s (2002) model of federal mandates demonstrates the operation of “the substitution principle”: in the presence of cross-regional spillovers, the high-demand regions decrease their public good production when they are able to implement federal mandates that are binding on lower-demand regions. The logic supporting “the substitution principle” is also operative in our model, albeit with significant caveats. If the benefits of high federal mandates for the rich regions in the Crémer and Palfrey model come largely from spillovers from public good in the poorer regions, the benefits of federal over local provision in our model come mainly from the fact that the federal level of provision allows the rich regions to force the poor regions to share the cost of provision, which would be beneficial even if the rich regions were enjoying no spillovers from the public good provided in the poor regions. We also show that, as the economic primitives vary, the incentives supporting the substitution principle in the model with both levels of provision are distributionally complex: the substitution effect is sometimes induced by an increase in local provision by the high-demanders, and at other times, by a decrease in federal provision supported by the low-demanders.[12]

At the same time, our results indicate the political appeal of federalism relative to other institutions managing relations between regions: when the existence of majority rule equilibrium can be assured, the "dual-provision" federalism receives majority support against confederation and fully centralized government regardless of whether the federal action would favor the wealthy or the poor member-regions. Given that the externalities that induce free-riding are the same ones that enhance the desirability of political integration in the first place, the inter-regional tensions we describe are likely to remain a central element of political economies in many countries in the foreseeable future.

Another increasingly important element in the EU and similar settings is voter mobility across political and economic jurisdictions. Although systematically incorporating this element into our analysis is beyond the scope of the current paper, we would expect it to reinforce the results obtained above when the Tiebout hypothesis (Tiebout 1956) holds. On the one hand, all voters would, *ceteris paribus*, prefer lower taxes and so would be interested in moving into low-tax jurisdictions; on the other, the marginal utility of additional units of public good is higher for the wealthier voters, and so the benefits of remaining in jurisdictions providing higher quantities of public good is higher. Our expectation is, then, that the first-order effect of voter mobility would be the poor voters moving into lower-tax jurisdictions in expectation of the spillover effects from wealthier regions, and the wealthy voters remaining in the higher-demand regions - reproducing, and perhaps, deepening, the distributive tensions characterized above.

Appendix

Lemma 1

Proof Suppose for some pair of regions j and k, $H_j > H_k$. We first show that if j is a local provider, then so must be k. The proof is by contradiction. Let $t_k H_k > 0$ and suppose that

[12] In a companion paper (***), we show that the logic of the substitution principle in the present model inhibits the possibility of "enhanced cooperation" among subsets of union members.

$t_j H_j = 0$. Then, from (4)

$$\frac{b}{a+b}(1-t^F)H_j \leq \frac{a}{a+b}(t^F H^T s_F + s_L \sum_{N\backslash j} t_l H_l). \tag{9}$$

From $H_j > H_k$,

$$\frac{b}{a+b}(1-t^F)H_k < \frac{a}{a+b}(t^F H^T s_F + s_L \sum_{N\backslash j} t_l H_l). \tag{10}$$

Because $t_j H_j = 0$, $s_L \sum\limits_{N\backslash j} t_l H_l = s_L \sum\limits_{N\backslash k} t_l H_l + s_L t_k H_k$. Making this substitution in (10) and re-arranging, we obtain

$$\frac{b}{a+b}(1-t^F)H_k - \frac{a}{a+b}(t^F H^T s_F + s_L \sum_{N\backslash k} t_l H_l) < \frac{a}{a+b} s_L t_k H_k. \tag{11}$$

From (4) and $t_k H_k > 0$, the left-hand side of this inequality must be equal to $t_k H_k$. Since, by assumption, $s_L < 1$, it follows that $\frac{a}{a+b} s_L < 1$, and so (11) is a contradiction.

We next show the result. If $t_k H_k = 0$, then $t_j H_j \geq t_k H_k$ and the result follows trivially. So, consider $t_k H_k > 0$. From the preceding, it must be, then, that $t_j H_j > 0$, and it follows from (4) that

$$\begin{aligned} t_k H_k &= \frac{b}{a+b}(1-t^F)H_k - \frac{a}{a+b}(t^F H^T s_F + s_L(\sum_{N\backslash j,k} t_l H_l + t_j H_j)) \\ t_j H_j &= \frac{b}{a+b}(1-t^F)H_j - \frac{a}{a+b}(t^F H^T s_F + s_L(\sum_{N\backslash j,k} t_l H_l + t_k H_k)). \end{aligned}$$

Substituting $t_k H_k$ into $t_j H_j$ and re-arranging, we get

$$\begin{aligned} t_j H_j &= \frac{a+b}{a+b+as_L}(\frac{b}{a+b}(1-t^F)H_j - \frac{a}{a+b}(t^F H^T s_F + s_L \sum_{N\backslash j,k} t_l H_l)) \\ &\quad + \frac{(a+b)^2}{(a+b+as_L)(a+b-as_L)} \frac{a}{a+b} s_L \frac{b}{a+b}(1-t^F)(H_j - H_k). \end{aligned}$$

Doing the opposite substitution, we get

$$\begin{aligned} t_k H_k &= \frac{a+b}{a+b+as_L}(\frac{b}{a+b}(1-t^F)H_k - \frac{a}{a+b}(t^F H^T s_F + s_L \sum_{N\setminus j,k} t_l H_l)) \\ &\quad + \frac{(a+b)^2}{(a+b+as_L)(a+b-as_L)} \frac{a}{a+b} s_L \frac{b}{a+b}(1-t^F)(H_k - H_j). \end{aligned}$$

Comparing these two expressions, it is easy to see that from $H_j > H_k$, and $a, b, s_L, s_F > 0$, and $t^F < 1$, it follows that $t_j H_j > t_k H_k$. ■

Lemma 2

Proof Fix t^F. We prove by contradiction. Let L^* and L^{**} both satisfy (7). From Lemma 1, participation is monotonic, so, without loss of generality, let $L^* \subseteq L^{**}$ and $l^{**} = l^* + n$. Because L^* satisfies (7),

$$(a+b+as_L(l^*-1))b(1-t^F)H_{l^*+1} \leq abs_L(1-t^F)\sum_{k\in L^*} H_k + (a+b-as_L)as_F t^F H^T. \quad (12)$$

Because L^{**} satisfies (7),

$$(a+b+as_L(l^{**}-1))b(1-t^F)H_{l^{**}} > abs_L(1-t^F)\sum_{k\in L^{**}} H_k + (a+b-as_L)as_F t^F H^T.$$

Substituting $l^{**} = l^* + n$ and $\sum_{k\in L^{**}} H_k = \sum_{k\in L^*} H_k + \sum_{k=l^*+1}^{l^{**}} H_k$ and re-arranging terms,

$$\begin{aligned} &(a+b+as_L(l^*-1))b(1-t^F)H_{l^{**}} - abs_L(1-t^F)(\sum_{k=l^*+1}^{l^{**}} H_k - nH_{l^{**}}) \\ &\qquad > abs_L(1-t^F)\sum_{k\in L^*} H_k + (a+b-as_L)as_F t^F H^T. \end{aligned}$$

The conjunction of this inequality and (12) implies

$$\begin{aligned} &(a+b+as_L(l^*-1))b(1-t^F)H_{l^{**}} - abs_L(1-t^F)(\sum_{k=l^*+1}^{l^{**}} H_k - nH_{l^{**}}) \\ &\qquad > (a+b+as_L(l^*-1))b(1-t^F)H_{l^*+1}. \end{aligned}$$

But $H_{l^{**}} \leq H_{l^*+1}$ and $l^{**} = l^* + n$, a contradiction. $\blacksquare$

Proposition 1

The following lemmata are instrumental in establishing this proposition.

Lemma 3 *For* $j \leq l_{\max}$*,*

(1) if $(a+b-as_L)s_F H^T - (a+b+as_L(l_{\max}-1))(1-s_L)H_j - (a(1-s_L)^2+b)\sum_{k=1}^{l_{\max}} H_k > 0$*, then* $\frac{\partial u_k}{\partial t^F} > 0$ *for* $t^F \in [0, \hat{t}_k^F)$*,* $\forall k$ *such that* $j \leq k \leq l_{\max}$*;*

(2) if $(a+b-as_L)s_F H^T - (a+b+as_L(j-1))(1-s_L)H_j - bs_L\sum_{k=1}^{j} H_k < 0$*, then* $\frac{\partial u_k}{\partial t^F} < 0$ *for* $t^F \in [0, \hat{t}_j^F)$*,* $k \leq j$*.*

Proof (1) Suppose that $t_j \in (0, t_j^*(t^F))$. Substituting (5) and (6) into (3), we obtain an expression for indirect utility as a function of t^F. Differentiating with respect to t^F, collecting terms and eliminating common factors, we obtain that $\frac{\partial u_j}{\partial t^F} > 0$ for $t^F \in [0, \hat{t}_j^F)$ if and only if

$$a(X - (a+b-as_L)s_F H^T)Y + bX(Y - (a+b-as_L)s_F H^T) < (a+b)XYt^F, \tag{13}$$

where $X = (a+b-as_L)s_F H^T - (a+b+as_L(l(t^F)-1))(1-s_L)H_j - (a(1-s_L)^2+b)\sum_{k=1}^{l(t^F)} H_k$ and $Y = (a+b-as_L)s_F H^T - (a+b+as_L(l(t^F)-1))(1-s_L)H_j - bs_L\sum_{k=1}^{l(t^F)} H_k$. Because $a(1-s_L)^2 + b > b > bs_L$, $X < Y$.

Suppose some l, some $j \leq l_{\max}$ such that $X > 0$. Then $Y > 0$. Since $(X-(a+b-as_L)s_F H^T) < 0$ and $(Y-(a+b-as_L)s_F H^T) < 0$, (13) is satisfied for j, $\forall t^F$ such that $l(t^F) = l$. From X, if $X > 0$ at $l = l_{\max}$, then $X > 0$ $\forall t^F < \hat{t}_j^F$. Therefore if $X > 0$ at $l = l_{\max}$ for j, then $\frac{\partial u_j}{\partial t^F} > 0$ for $t^F \in [0, \hat{t}_j^F)$. Furthermore, from X and $H_j > H_{j+1}$, if $X > 0$ for j, then $X > 0$ $\forall k$ such that $j < k \leq l_{\max}$. Therefore if $X > 0$ at $l = l_{\max}$ for $j \leq l_{\max}$, then $\frac{\partial u_k}{\partial t^F} > 0$ for $t^F \in [0, \hat{t}_k^F)$, $\forall k$ such that $j \leq k \leq l_{\max}$.

(2) Suppose some l, some $j \leq l_{\max}$ such that $Y < 0$. Then $X < 0$. Then (13) fails for j, $\forall t^F$ such that $l(t^F) = l$. From Y, if $Y < 0$ at $l = j$, then $Y < 0$ $\forall t^F < \hat{t}_j^F$. Therefore if $Y < 0$ at $l = j$, then $\frac{\partial u_j}{\partial t^F} < 0$ for $t^F \in [0, \hat{t}_j^F)$. Furthermore, from Y and $H_j > H_{j+1}$, if $Y < 0$ for j, then $Y < 0$ for $k \leq j$. Therefore if $Y < 0$ for j at $l = j$, then $\frac{\partial u_k}{\partial t^F} < 0$ for $t^F \in [0, \hat{t}_j^F)$, $k \leq j$. $\blacksquare$

Lemma 4 *For any regions* j *and* k*, such that* $H_j \geq H_k$*,* $u_k(.) = (\frac{h_k}{h_j})^a u_j(.)$ *for all* $t^F \in (\hat{t}_j^F, 1]$*.*

Proof Suppose, without the loss of generality, that $H_j \geq H_k$ and consider the range of t^F where neither region is a local provider, i.e., $t^F \in (\hat{t}^F_j, 1]$. Substituting (5) into (3), we get j's consumption level, u_j, when j is not a local provider:

$$u_j(t^F) = ((1-t^F)h_j)^a(t^F H^T s_F + \frac{s_L}{a+b+as_L(l-1)}(b(1-t^F)\sum_{k\in L} H_k - as_F t^F H^T l))^b \quad (14)$$

Observe that, since the public good factor is independent of non-providers' characteristics, the amount of public good enjoyed by both j and k is the same. Re-arranging the factors, we can write, then, $u_j(t^F) = h_j^a Z$ and $u_k(t^F) = h_k^a Z$, where $Z = (1-t^F)^a(t^F H^T s_F + \frac{s_L}{a+b+as_L(l-1)}(b(1-t^F)\sum_{k\in L} H_k - as_F t^F H^T l))^b$. Substituting, we get $u_k(.) = (\frac{h_k}{h_j})^a u_j(.)$. It follows that the preferences of all locally non-providing regions are, on the corresponding range of t^F, isomorphic. By implication, locally optimal federal tax rates and the orderings of any two locally optimal t^F for all regions that do not engage in local provision at those tax rates must be identical. ■

Proof of Proposition 1 From part 1 of Lemma 3, $f(j, a, b, s_L, s_F, H) = (a+b-as_L)s_F H^T - (a+b+as_L(l_{\max}-1))(1-s_L)H_j - (a(1-s_L)^2+b)\sum_{k=1}^{l_{\max}} H_k$.

(1) Established by Lemma 3.

(2) By part (1) of this proposition, $t_1^{F*} > \hat{t}_1^F$. From Lemma 1, $\hat{t}^F_{j+1} < \hat{t}^F_j \; \forall j \leq l_{\max}$. From Lemma 4, region $j+1$ has a local maximum at every local maximum of j on $[\hat{t}^F_j, 1]$, and the greatest of them is identical to that of j. From Lemma 3, if $j+1$ has another local maximum, it must be on $[\hat{t}^F_{j+1}, \hat{t}^F_j]$. Thus, either $t^{F*}_{j+1} = t^{F*}_j$ or $t^{F*}_{j+1} < t^{F*}_j$. $\forall j > l_{\max}$, Lemma 4 implies that j's greatest local maximum on $[\hat{t}^F_{l\max}, 1]$ is at $t^{F*}_{l\max}$. Thus, either $t^{F*}_j = t^{F*}_{l\max}$ or $t^{F*}_j \leq \hat{t}^F_{l\max} \leq t^{F*}_{l\max}$.

(3) Let t^{F*} be the globally optimal federal tax rate for the region with median income. By Lemma 3, $t^{F*} > \hat{t}^F_m$. By part (1) of this proposition, for all regions j poorer than the median, $t^{F*} > \hat{t}^F_j$. From Lemma 4, the median region's preference for t^{F*} implies that all poorer regions also prefer t^{F*} to any $t^F > t^{F*}$. Hence t^{F*} beats any $t^F > t^{F*}$ by majority rule. For region j richer than the median, j either engages in local provision at t^{F*}, and hence, from Lemma 3, prefers t^{F*} to any $t^F < t^{F*}$, or does not engage in local provision, in which case it also has a local optimum

at t^{F*}. From Lemmata 1 and 4, no region richer than the median has a local optimum that is not also a local optimum of the median. By Lemma 4, any region j that is richer than the median and does not engage in local provision at t^{F*} prefers t^{F*} to any $t^F \in [\hat{t}_j^F, t^{F*})$. From Lemma 3, j also prefers $\hat{t}_j^F$ to any $t^F < \hat{t}_j^F$, and therefore prefers t^{F*} to any $t^F < \hat{t}_j^F$. Thus, all regions richer than the median prefer t^{F*} to any $t^F < t^{F*}$, and so t^{F*} is the Condorcet winner.

(4) Follows immediately from parts (1) and (2). ■

Proposition 2

Proof From Lemma 3, $g(j, a, b, s_L, s_F, H) = (a + b - as_L)s_F H^T - (a + b + as_L(j-1))(1 - s_L)H_j - bs_L \sum_{k=1}^{j} H_k$.

(1) Established by Lemma 3.

(2) From Lemma 3, $\hat{L} = \{1, ..., \hat{l}\}$ and $\forall j \leq \hat{l}$, $t_j^{F*} = 0$. By the argument in the proof of part (2) of Proposition 1, $\forall j > \hat{l}$, t_j^{F*} is weakly monotone increasing in income. By assumption, $\hat{l} \geq 1$. If $\hat{l} < n$, then t_j^{F*} is non-monotonic in income; if $\hat{l} = n$, then $t_j^{F*} = 0\ \forall j$.

(3) If $m \leq \hat{l}$, then $\hat{L}$ constitutes a majority. Suppose $m > \hat{l}$. From Lemmata 4 and 1, $\forall j \geq m+\hat{l}$, $t_{m+\hat{l}}^{F*}$ is preferred to any $t^F > t_{m+\hat{l}}^{F*}$. $\forall j \leq \hat{l}$, $t_{m+\hat{l}}^{F*}$ is preferred to any $t^F > t_{m+\hat{l}}^{F*}$. Together these regions constitute a majority. From Lemmata 4 and 1, $\forall j$ such that $\hat{l} < j \leq m+\hat{l}$, either $t_j^{F*} = t_{m+\hat{l}}^{F*}$ or $\hat{t}_j^F > t_{m+\hat{l}}^{F*}$. From Lemma 3, if $\hat{t}_j^F > t_{m+\hat{l}}^{F*}$ then j strictly prefers $t_{m+\hat{l}}^{F*}$ to any $t^F < t_{m+\hat{l}}^{F*}$. Thus a majority prefers $t_{m+\hat{l}}^{F*}$ to any $t^F < t_{m+\hat{l}}^{F*}$.

(4) Part (4) is an immediate consequence of Lemmata 3 and 4. ■

Proposition 3

Proof Region j prefers local to federal provision if and only if $\frac{\partial u_j}{\partial t_j} > \frac{\partial u_j}{\partial t^F}$, which holds (with $s_L = 0$) if and only if $H_j > s_F H^T$. It follows that when this inequality holds, $t_j^{F*} = 0$. If $H_j < s_F H^T$, then $\frac{\partial u_j}{\partial t^F} = 0$ at $t_j^{F*} = \frac{b}{a+b}$. Substituting $s_L = 0$ into 4 and simplifying, $t_j^*(t^F) = \max\{0, \frac{1}{a+b}(b(1-t^F) - as_F \frac{H^T}{H_j} t^F)\}$. From $t_j^*(t^F)$, there is a unique value of t^F, $\hat{t}_j^F$, s.t. $t_j^*(t^F) = 0$ for all $t^F \geq \hat{t}_j^F$. Suppose, first, that $t^F \leq \hat{t}_j^F$. Substituting $t_j^*(t^F)$ into $u_j(t^F, t_j)$, $\frac{\partial u_j}{\partial t^F} > 0$ if and only if $H_j < s_F H^T$. It follows that $t_j^{F*} \geq \hat{t}_j^F$ if $H_j < s_F H^T$, and either $t_j^{F*} = 0$ or $t_j^{F*} \geq \hat{t}_j^F$ if $H_j > s_F H^T$. Suppose now that $t^F \geq \hat{t}_j^F$. Substituting $t_j = 0$ into $u_j(t^F, t_j)$, $\frac{\partial u_j}{\partial t^F} > 0$ for all $t^F < \frac{b}{a+b}$, $\frac{\partial u_j}{\partial t^F} = 0$ at $t^F = \frac{b}{a+b}$, and $\frac{\partial u_j}{\partial t^F} < 0$ for all $t^F > \frac{b}{a+b}$. If $H_j \leq s_F H^T$, then $\hat{t}_j^F \leq \frac{b}{a+b}$ and j's consumption is monotone increasing in t^F for all $t^F \leq \frac{b}{a+b}$ and monotone decreasing in t^F for all $t^F \geq \frac{b}{a+b}$. If $H_j > s_F H^T$, then $\hat{t}_j^F > \frac{b}{a+b}$ and j's consumption is monotone decreasing in t^F. It follows that j's preferences are single-peaked for all $j \in N$, and the application of the median-voter theorem yields the conditions in the statement of the proposition. ■

Proposition 4

Proof (1) Suppose that $s_F < \frac{H_m}{H^T}$. If $s_L = 0$, then, by Proposition 3, $t^{F*} = t_m^{F*} = 0$ and $t_j = \frac{b}{a+b}\ \forall j \leq m$. Suppose that $s_L > 0$. Then, holding t^F and t constant, $\forall j \in N$, y_j increases, and x_j is constant. It follows that j's marginal benefit of y_j decreases, and of x_j increases. Because local provision remains more efficient than federal $\forall j \leq m$, t^{F*} remains 0, and $\forall j \in N$, t_j decreases.

(2) Suppose that $s_F > \frac{H_m}{H^T}$. If $s_L = 0$, then, by Proposition 3, $t^{F*} = \frac{b}{a+b}$ and $t_j = 0\ \forall j \geq m$. Suppose first that if $s_L = 0$, then $\forall j$, $t_j^*(\frac{b}{a+b}) = 0$. Then, if $s_L > 0$, then $\forall j$, $t_j^*(\frac{b}{a+b}) = 0$. Hence, if $s_L > 0$, either $t^{F*} = \frac{b}{a+b}$ and $t^* = 0$ or $t^{F*} < \hat{t}_1^F < \frac{b}{a+b}$, $t_1^*(t^{F*}) > 0$, and $\forall j > 1$, $t_j^*\left(t^{F*}\right) \geq 0$. Suppose, then, that $t_1^*(\frac{b}{a+b}) > 0$ for $s_L = 0$. $\forall j$ s.t. $t_j^*(\frac{b}{a+b}) = 0$, $t^F = \frac{b}{a+b}$ is a maximum of $u_j(t^F, t^*(t^F), s_L = 0)$. If, holding constant t^F and t, $s_L > 0$, then $\forall j$, y_j increases and x_j is constant. Hence, $\forall j$ s.t. $t_j^*(\frac{b}{a+b}) = 0$ at $s_L = 0$, t_j^{F*} decreases in s_L and so a majority prefers $t^{F*} < \frac{b}{a+b}$ at $s_L > 0$. It follows that if $s_L > 0$, $\exists j \geq m$ s.t. $t^{F*} = t_j^{F*}$. Because $H_m < s_F H^T$, $t_j^*(t_j^{F*}) = 0$, $y_j = s_F H^T t^{F*} + s_L \sum_{L(t^{F*})} t_k H_k$.

Let k be such that at $s_L = 0$, $t^F = \frac{b}{a+b}$, $t_k^*(\frac{b}{a+b}) > 0$. Then, $H_k > H_j$ and, holding t_k constant, $-\frac{\partial x_k}{\partial t^F} > -\frac{\partial x_j}{\partial t^F}$. It follows that as t^F decreases, the amount of public good desired by k increases faster than the amount desired by j. At $s_L = 0$, $t^F = \frac{b}{a+b}$, $y_k = y_j + t_k^*(\frac{b}{a+b}, s_L = 0)$. Hence, at $s_L > 0$, $t^{F*} < \frac{b}{a+b}$, and $y_k\left(t^{F*}, s_L > 0\right) > y_j(t^{F*}, s_L > 0) + t_k^*(\frac{b}{a+b}, s_L = 0)$, which is equivalent to

$$
\begin{aligned}
s_F H^T t^{F*} + (1 - s_L) t_k^*(t^{F*}, s_L &> 0) + s_L \sum_{L(t^{F*})} t_h^*(t^{F*}) H_h \\
&> s_F H^T t^{F*} + s_L \sum_{L(t^{F*})} t_h^*(t^{F*}) H_h + t_k^*(\frac{b}{a+b}, s_L = 0).
\end{aligned}
$$

Reducing, we obtain that $s_L < 1$ implies that $t_k^*(t^{F*}, s_L > 0) > t_k^*(\frac{b}{a+b}, s_L = 0)$, completing the proof. ■

Proposition 5[13]

Proof (1) Denote the outcome of a federation $(t^{F*}, t^*(t^{F*}))$, of confederation $(0, t^*(0))$, and of complete centralization $(\frac{b}{a+b}, 0)$. By definition of t^{F*}, $(t^{F*}, t^*(t^{F*}))$ is preferred to $(\frac{b}{a+b}, t^*(\frac{b}{a+b}))$ by a majority of regions, and is strictly preferred if $t^{F*} \neq \frac{b}{a+b}$. For every region, $(\frac{b}{a+b}, t^*(\frac{b}{a+b}))$ is at least as good as $(\frac{b}{a+b}, 0)$, and it is strictly better if $t^*(t^F) > 0$. Thus a majority always prefers federation to complete centralization. By definition of t^{F*}, $(t^{F*}, t^*(t^{F*}))$ is preferred to $(0, t^*(0))$ by a majority of regions, and is strictly preferred if $t^{F*} \neq 0$. Thus a majority always prefers federation to confederation.

(2) From part 3 of Proposition 1, t_m^{F*} and $t = t^*(t_m^{F*})$ are the equilibrium outcomes in a federation. From part 2 of Proposition 1, $\{m, ..., n\}$ prefer $t^F = t_m^{F*}$ and $t = t^*(t_m^{F*})$ to $t^F = \frac{b}{a+b}$ and $t = t^*(\frac{b}{a+b}) = 0$, and strictly prefer the former if $t_m^{F*} \neq \frac{b}{a+b}$. From part 1 of Proposition 1, $t_m^*(t_m^{F*}) = 0$. From Lemmata 4 and 1, $\{1, ..., m\}$ strictly prefer $t^F = t_m^{F*}$ and $t = t^*(t_m^{F*})$ to $t^F = 0$ and $t = t^*(0)$.

(3) From part 3 of Proposition 2, $t_{m+\hat{l}}^{F*}$ and $t = t^*(t_{m+\hat{l}}^{F*})$ are the equilibrium outcomes in a federation if $m > \hat{l}$, and $t^{F*} = 0$ and $t = t^*(0)$ otherwise. From parts 1 and 2 of Proposition 2, if $m > \hat{l}$, $\{\hat{l}+1, ..., m+\hat{l}\}$ prefer $t^F = t_{m+\hat{l}}^{F*}$ and $t = t^*(t_{m+\hat{l}}^{F*})$ to $t^F = 0$ and $t = t^*(0)$, and strictly prefer the former if $t_{m+\hat{l}}^{F*} \neq 0$. If $m \leq \hat{l}$, they are indifferent. If $m > \hat{l}$ and $t_{m+\hat{l}}^{F*} \neq 0$, then $t_{m+\hat{l}}^*(t_{m+\hat{l}}^{F*}) = 0$. From Lemmata 4 and 1, $\{m+\hat{l}, ..., n\}$ strictly prefer $t^F = t_{m+\hat{l}}^{F*}$ and $t = t^*(t_{m+\hat{l}}^{F*})$ to $t^F = \frac{b}{a+b}$ and $t = t^*(\frac{b}{a+b}) \neq 0$. From part 1 of Proposition 2, $\{1, ..., \hat{l}\}$ also strictly prefer $t^F = t_{m+\hat{l}}^{F*}$ and $t = t^*(t_{m+\hat{l}}^{F*})$ to $t^F = \frac{b}{a+b}$ and $t = t^*(\frac{b}{a+b}) \neq 0$. All agents in $\{1, ..., \hat{l}\} \cup \{m+\hat{l}, ..., n\}$ strictly prefer the latter to $t^F = \frac{b}{a+b}$ and $t = 0$. ■

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