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Matching Grants, Income Redistribution and Decentralized Leadership

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Abstract: We examine the decentralized provision of an impure public good by regional governments in a federation similar in certain respects to both the European Union and the United States. The central authority redistributes income and provides matching grants on a per rate basis *after* it observes the regions' contributions to the impure public good. Imperfectly mobile workers react to regional and central governments' policies by establishing residence in their most preferred region. Despite imperfect labor mobility, we show that the allocation of the impure public good and the interregional income redistribution policy are generally efficient in a federation with decentralized leadership.

Key words: Decentralized Leadership; Federation; Redistribution; Labor Mobility; Matching Grants.

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Impure Public Goods, Matching Grant Rates and Income Redistribution in a Federation with Decentralized Leadership and Imperfect Labor Mobility

Abstract: We examine the decentralized provision of an impure public good by regional governments in a federation similar in certain respects to both the European Union and the United States. The central authority redistributes income and provides matching grants on a per rate basis *after* it observes the regions' contributions to the impure public good. Imperfectly mobile workers react to regional and central governments' policies by establishing residence in their most preferred region. We show that the allocations of the impure public good and the population are generally efficient in a federation with decentralized leadership.

I. Introduction

Matching grant policies are pervasive in both the United States (US) and the European Union (EU). In the US, for instance, the Department of Transportation's Federal Highway Administration (FHWA) offers individual states (through its Federal-aid Highway Program) a 90% matching-grant subsidy for construction and preservation of the interstate highway system and an 80% subsidy for projects unaffiliated with the interstate system (FHWA, 2006). The Department of Health and Human Services (DHHS) similarly awards competitive matching grants to voluntary agencies for coordinating refugee services nationwide, and it matches (at 50% to 85% "federal medical assistance percentages") state-level contributions toward Medicaid and the Children's Health Insurance Program (DHHS, 2006a and 2006b). In addition, the individual states themselves offer a myriad of competitive matching-grant subsidies to neighbourhoods and cities for community development purposes. In the EU, the Cohesion Fund provides 85% matching-grant subsidies for "structural" (i.e., infrastructural) improvements mainly in the southern European nations, and the European Commission's matching-grant program similarly helps to fund "capacity enlargement" (e.g., of public administration and nongovernmental organizations) in new member states, e.g., in Malta, Slovenia, Czech Republic, and Hungary (European Commission, 2006; Fenge and Wrede, 2004).

The literature on impure public goods (or “impure altruism”) provides a precedent for matching-grant rates. However, this literature has been primarily concerned with the issue of neutrality, not efficiency per se. For example, Andreoni (1989, 1990) finds that neutrality generally does not hold for the case of impure public goods. The reasoning behind this result is that a "warm glow effect" makes private contributions imperfect substitutes for contributions from other sources, such as public good provision from other contributors or taxes and subsidies from the central government. Without perfect substitutability of contributions,...“transfers of income [in the form of direct or matching grants] to the more altruistic from the less altruistic increases the equilibrium supply of the public good” (Andreoni, 1990).

While the literature on impure public goods has clearly identified the properties and behavioral assumptions underlying the neutrality hypothesis, it has not adequately answered the question of which policy instruments and hierarchical structures are necessary to *completely* reverse the neutrality result. In other words, how do we move beyond Pareto dominant outcomes for impure public good provision to the complete set of Pareto efficient solutions? To answer this question, we analyse the class of impure public goods within the framework of a federation, similar to that of Caplan, et al. (2000).[1]

In the federal regime envisioned in this paper, regional authorities are Stackelberg leaders and the central authority is a Stackelberg follower. As far as we know, the first paper to examine a hierarchical federation characterized by decentralized leadership setting was Silva and Caplan (1997). These authors were the first to use the terminology “decentralized leadership” to describe a hierarchical federation in which regional governments are policy leaders and the central government is a policy follower. These authors show that if regional preferences are quasilinear and the center cares about equity, as captured by the strict concavity of its objective function with respect to income transfers, the subgame perfect equilibrium for the decentralized leadership game is indeed Pareto efficient.[2]

[1]Federations are hierarchical organizations characterized by the coexistence of governments at the central, regional (i.e., state or province) and local levels. At each level a government is typically endowed with a set of policy instruments which it utilizes to foster its own objectives, such as the provision of public services and goods. In general, the economic jurisdiction of a public good provided regionally or locally exceeds the political jurisdiction of the regional or local government. Impure public goods, such as abatement of a transboundary pollutant and infrastructure projects, provide good examples of this.
[2] More recently, Kothënburger (2004), Akai and Sato (2008) and Breuillé et al (2009) have examined the efficiency of decentralized leadership policy making under various settings. For example, Akai and Sato consider a setting in

This decentralized leadership framework seems to be a fair representation of the EU, where the governments of the member nations have historically pre-committed to their own public good policies – the environmental policies of the member nations provide good examples – and the central government, through the Maastricht Treaty, has been endowed with significant power (e.g., via Structural and Cohesion Funds) to redistribute income amongst and provide matching grants to the member nations after it observes these nations' public good policies. The allocation of the Structural and Cohesion Funds obeys the 'additionality' principle, whereby the center's role is restricted to the provision of additional resources to help member nations execute their own policies – such as infrastructure development and pollution abatement. Similarly in the US, the central government's income-redistribution policy typically redistributes income across individuals regardless their regions of residence, and its matching grant policies effectively redistribute income across the various states.

In what was the first model of a federation with imperfect labor mobility (or regional attachment benefits) and spillover-inducing public good provision, Wellisch (1994) shows that at least one region under-supplies the pubic good.[3] This inefficiency result is important because it relates to the case of imperfect labor mobility. However, similar to Andreoni's (1989, 1990) neutrality result for impure public goods, it leaves unanswered the questions of which policy instruments and what type of hierarchical structures are capable of achieving a socially efficient allocation of public good provision within such a federation.

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which the center has an explicit taste for equity and replicate the result obtained by Caplan et al (2000), but only when the spillover is perfect – i.e., the case of a pure federal good. They claim that such an efficiency result holds only under such a circumstance. As in Silva and Caplan (1997), Caplan and Silva (1999), Caplan et al. (2000) and Akai and Sato (2008), we postulate that the center has a taste for equity, as captured by the strict concavity of its objective function with respect to income transfers. Unlike Caplan et al. (2000) and Akai and Sato (2008), we demonstrate that federal policy making may be efficient even when the regional public contributions are impure.

[3] Mansoorian and Myers (1993) were the first to model imperfect labor mobility in the context of local public goods, building on the model of perfect mobility developed by Boadway (1982).

Caplan, et al.(2000) provide one possible answer for the case of pure public goods. They show that, irrespective of the degree of labor mobility, a federation characterized by "decentralized leadership" and identical preferences implements efficient public good policies at an interior solution. In this framework, decentralized leadership means that the central government makes interregional income transfers *after* it observes the contributions to the pure public good made by the regional governments. By pre-committing to their public good contributions in anticipation of the center's interregional income policy and subsequent labor mobility, each region therefore has no incentive to deviate from the socially-efficient allocation in the resulting sub-game perfect equilibrium. However, left unanswered by Caplan, et al. (2000) is the question of whether or not this type of decentralized leadership is strong enough to implement efficient policies for impure public goods in the face of imperfect labor mobility.

The present paper answers this question in the affirmative, but only when the central government is provided with an additional policy instrument – matching grant rates. [4] In what follows, we consider two governmental regimes. Section 2 introduces our basic model and examines a regime where the central authority controls all policy instruments. Given our assumptions about regional welfare functions and the central authority's objective function – a weighted sum of the regional governments' objective functions – we are able to derive as a benchmark the entire set of Pareto efficient allocations.[5] An alternative regime, denoted "decentralized leadership," is characterized in Section 3 by the central authority being solely endowed with an instrument to make interregional income transfers, and, later, matching grant

[4] Recent papers show that decentralized leadership is efficient in the presence of impure public goods when the central government is Rawlsian (Aoyama and Silva (2008, 2010)) and when the competing regions create a market for the impure public good (Silva and Yamaguchi (2010)). Here, we consider the alternative efficiency enhancing role played by matching grants.

[5] See Wellisch (1994) for the case where each region independently controls the level of the transfer that it makes to the other region. Wellisch (1994) shows that while the Nash solution is efficient with respect to population distribution, it is inefficient with respect to the allocation of the public good.

rates. In this section, we show that the central authority's income-redistributive ability alone is not sufficient to restore the Pareto efficient allocation of public good provision across the two regions. However, when the central authority retains control over both income redistribution and matching-grant rates, financed by budget-balanced lump-sum taxation, the efficient allocation of public good provision is restored. In Sections 2 and 3, labor is assumed to be imperfectly mobile, a characterization of the EU's common labor market as well as the national labor market in the US. Section 4 summarizes our results and discusses the model's main limitations.

2. The Basic Model and Pareto Efficient Benchmark

Imagine a federation with two regions, indexed by j, $j = 1,2$, two attendant regional governments and one central government. There are N individuals in the federation. The population of region j is denoted n_j. Without loss of generality, assume that $0 < n_j < 1$ and $N = \sum_j n_j = 1$, implying that $n_2 = 1 - n_1$. The utility of the representative resident of region j, is assumed to be

$$v^j = \begin{cases} u^1(x_1, q_1, Q) + a(1-n), & \text{if the resident lives in 1,} \\ u^2(x_2, q_2, Q) + an, & \text{if the resident lives in 2.} \end{cases} \tag{1}$$

where, following Andreoni (1989, 1990), u^j, $j = 1,2$, is strictly concave and increasing in all arguments, x_j is the consumption of the private (or numeraire) good, q_j denotes the amount of public good provided by region j (i.e. the "egoistic" component of welfare), and $Q = \sum_j q_j$ represents the federation's aggregate amount of the public good, or the "altruistic" component of welfare.[6] As in Wellisch (1994) and Caplan, et al. (2000), parameter n ($0 < n < 1$) measures the

[6] The curvature conditions on u^j, as well as on f^j discussed below, generally ensure the existence of concave programming problems for each of the cases considered below and thus ensure that sufficient second-order conditions are satisfied for each of the maximization problems considered below. It is well-known that without further restrictions on these two functions, externalities can be the source of non-convexities even when both functions are strictly concave throughout, resulting in the possible existence of corner solutions (in our model's case, the emptying out of one of the two regions due to both migration and public-good effects) or multiple local social

psychic benefit a resident derives from living in region *2* and the parameter *(1 - n)* the benefit from living in region *1*. Thus, residents with relatively small n's ($n \in [0, n_1]$) are at home in region *1*, while residents with relatively large n's ($n \in [n_1, 1]$) are at home in region *2* (household n_1 can therefore be thought of as the marginal household). The parameter a $(a > 0)$ expresses the degree of heterogeneity in tastes for a region. The larger is a, the greater the intensity of psychic attachment to a respective region.

Each resident of region j is endowed with one unit of labor which is supplied in region j. Workers in a region are assumed to be identically productive and are employed in the production of the numéraire good. The production possibilities for the numéraire good are represented by a strictly concave production function $F^j(n_j; L_j) = f^j(n_j)$, where L_j denotes region j's fixed resource endowment, say land. Since workers are identically productive and are all employed in the production of the numéraire good, we assume that each individual's total return from the productive activity in region j is $f^j(n_j)/n_j$.

The numéraire good is not only used for consumption, but also as an input in the production of the impure public good, at a constant marginal cost of 1. Regional government j can therefore produce q_j units of the public good at a total cost of q_j. Further, we assume that relative prices are constant, and that units of all commodities are chosen so that their prices are equal to 1.[7] Each resident of region j, faces the following budget constraint:

$$\frac{f^j(n_j)}{n_j} = \begin{cases} x_1 + \dfrac{q_1 + \tau_1 - \tau_2}{n_1} & \text{if the resident lives in 1,} \\ x_2 + \dfrac{q_2 + \tau_2 - \tau_1}{n_2} & \text{if the resident lives in 2.} \end{cases} \qquad \text{j=1,2,} \tag{2}$$

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optima (Starrett, 1972 and Baumol and Oates, 1988). We acknowledge the possibility of these types of solutions, yet restrict our focus to interior Pareto efficient solutions (see below), as well as interior decentralized equilibria, and impose a migration-equilibrium stability condition to ensure the stability of the model's decentralized equilibria.

[7] As noted in Boadway et al. (1989), linear production technology assures both constant marginal costs and prices.

where, for each j, the right-hand side shows the resident's total expenditure and the left-hand side gives his total income. The representative resident of region j transfers an amount τ_j/n_j to region $-j$, and receives an amount τ_{-j}/n_j from region $-j$.

In the decentralized model to follow, households are free to choose where they will reside. Since they differ in their attachment to a region, the migration equilibrium is characterized by marginal household n_1, which is indifferent between locating in either region. Substituting (2) into (1), and recalling $n_2 = 1 - n_1$, the decentralized migration equilibrium may therefore be expressed as:

$$u^1\left(\frac{f^1(n_1)-q_1-\tau_1+\tau_2}{n_1},q_1,Q\right)+a\left(1-n_1\right)=u^2\left(\frac{f^2(1-n_1)-q_2-\tau_2+\tau_1}{1-n_1},q_2,Q\right)+an_1. \qquad (3)$$

To determine the Pareto-efficient solution, we assume the following objective function for the central authority:[8]

$$W\left(x_1,x_2,q_1,q_2\right)=\theta u^1\left(x_1,q_1,Q\right)+\left(1-\theta\right)u^2\left(x_2,q_2,Q\right). \qquad (4)$$

where parameter $\theta \in (0,1)$ corresponds to the weight applied to region 1's welfare by the central authority. We assume that this parameter is determined exogenously by either egalitarian, institutional, or political considerations. For a fixed θ, we obtain efficient population and public good allocations by choosing $\{x_j, q_j\}_{j=1,2}$ to maximize (4) subject to (3) and the aggregate

[8]Recently, Aoyama and Silva (2009) show that neglecting attachment benefits in regional and social welfare functions are not without loss of generality if the regional governments are Rawlsian and social welfare is a strictly concave transformation of regional welfare levels. In such circumstances, the regional governments wish to maximize the utility of their least off residents, which in the attachment model correspond to the resident who is just indifferent between residing in either region. In this paper, the regional governments are not Rawlsian. Hence, there is no loss in generality of neglecting attachment benefits in the social welfare function (4). Its maximization subject to (3), which includes individual attachment benefits, characterizes a Pareto efficient allocation for a given weight θ. Any change in location must be accompanied by an increase in either u^1 or u^2; otherwise it would not be made. This straightforward revealed- preference argument explains why a Pareto efficient allocation must maximize (4) (see, e.g., Wellisch (1994, p. 171)).

resource constraint for the federation (which is found by summing the regional budget constraints in (2)):

$$n_1x_1 + n_2x_2 + Q = f^1(n_1) + f^2(n_2). \tag{5}$$

The set of Pareto efficient allocations, excluding the efficient allocations associated with $\theta = 0$ and $\theta = 1$, can then be derived by straightforward application of the envelope theorem, namely, by varying θ between 0 and 1 and computing the efficient allocation associated with each particular θ value. As shown in Appendix 1, for a fixed θ an efficient allocation under imperfect labor mobility is characterized by (3), (5), and the following equations, provided the solution is interior:[9]

$$n_j \frac{u_q^j}{u_x^j} + \left(n_1 \frac{u_Q^1}{u_x^1} + n_2 \frac{u_Q^2}{u_x^2} \right) = 1, \quad j = 1,2. \tag{6}$$

$$-\frac{2an_2}{u_x^2} \le \left(f_n^1 - x_1\right) - \left(f_n^2 - x_2\right) \le \frac{2an_1}{u_x^1}. \tag{7}$$

Equations (6) are the modified Samuelson conditions for efficient provision of the impure public good. They show that the *sum* of the MRS's between the public and numeraire goods in consumption equal the marginal rate of transformation between these two goods in production. For future reference, we note that equations (6) are indeed compatible with an interior solution for non-symmetrical agents. This is due to the inclusion of the egoistic terms u_q^j in the respective equations (see Chiappori and Werning (2002) for further details). Further, equations (6) imply

$$n_1 \frac{u_q^1}{u_x^1} = n_2 \frac{u_q^2}{u_x^2}, \tag{8}$$

[9] The subscripts on functions u^j and f^j represent the partial derivatives with respect to the variable indicated.

or that the regions provide the public good up to the point where the sum of their respective MRSs between the egoistic components of individual preferences are equated.

Equation (7) is the efficient population distribution condition (see Wildasin (1986) and Wellisch (1994) for further discussion). The population distribution indicated by (7) is a direct result of the equal-utility migration equilibrium (3). Equations (7) and (8) are thus the benchmark conditions for Pareto efficiency.

3. Decentralized Leadership with Centralized Income Redistribution and Matching Grants

We initially consider a three-stage game whereby the regional governments, acting as Stackelberg leaders, pre-commit in the initial stage by selecting their contributions to the public good prior to the interregional income redistribution policy of the central authority. The central authority then determines only its interregional income redistribution policy in the second stage of the game, after observing the public good contributions chosen by the regional governments and in anticipation of location choices made by residents. Residents make their location choices in the final stage after they observe both the contributions to the public good and the interregional redistributions of income. Except where noted, we assume imperfect labor mobility ($a > 0$) throughout.

Formally, the timing for the game is as follows:

Stage 1: Regional government 1 chooses non-negative q_1 to maximize $u^1(x_1, q_1, q_1 + q_2)$ subject to $x_1 = x_1(q_1, q_2)$. Regional government 2 chooses non-negative q_2 to maximize $u^2(x_2, q_2, q_1 + q_2)$ subject to $x_2 = x_2(q_1, q_2)$. Each regional government takes the other regional government's choice as given.

Stage 2: The central authority observes $\{q_1, q_2\}$ and chooses $\{x_j\}_{j=1,2}$ to maximize (4) subject to (5) and $n_1 = n_1(x_1, x_2, q_1, q_2)$.

Stage 3: After observing the choices made in stages 1 and 2, residents select their preferred residential locations.

Note that the central authority is capable of redistributing quantities of the numeraire good across the regions as it wishes provided that the economy-wide resource constraint (5) is not violated. Hence, for any choice of public good quantity made by each regional government, the central authority will effectively determine the final regional consumption levels of the numeraire good. In this sense, because the Notice that by construction the regional transfer instruments considered in the Nash equilibrium cancel themselves out when we sum regional resources in order to formulate the economy-wide resource constraint.

The migration equilibrium equation (3) enables us to define the implicit function for stage three:[10]

$$n_1 = n_1\left(x_1, x_2, q_1, q_2\right). \tag{9}$$

Assuming an interior solution, we obtain the following first order conditions for the central authority's second-stage maximization problem:[11]

$$\theta u_x^1 + \lambda\left(\left(f_n^1 - f_n^2 - x_1 + x_2\right)\frac{u_x^1}{2a} - n_1\right) = 0, \tag{10a}$$

$$\left(1-\theta\right)u_x^2 + \lambda\left(-\left(f_n^1 - f_n^2 - x_1 + x_2\right)\frac{u_x^2}{2a} - n_2\right) = 0, \tag{10b}$$

where $\lambda > 0$ is the shadow value of an additional unit of aggregate income for the federation. It is straightforward to show that combining (10a) with (10b) yields an efficient population distribution condition consistent with inequalities (7). Together, conditions (10) and the economy-wide resource constraint (5) enable us to implicitly define $\lambda = \lambda\left(q_1, q_2\right)$ and:

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[10]The corresponding explicit functions for (9), along with all other derivations for this section are included in Appendix 2.

[11]Due to the aforementioned curvature conditions on u^j and $f^j(n_j)$, the local sufficient second order condition is satisfied in the maximization problem of the second stage.

$$x_j = x_j\left(q_1, q_2\right), j = 1, 2. \tag{11}$$

In the first stage of the game, the regional governments choose their contributions to the public good taking into account the implicit functions (11). Assuming that $\{q_j > 0\}_{j=1,2}$, the first order conditions that characterize the Nash equilibrium in the first stage for regions 1 and 2, respectively, are as follows:[12]

$$u_x^1 \frac{\partial x_1}{\partial q_1} + u_q^1 + u_Q^1 - a\Omega_1 = 0, \tag{12a}$$

$$u_x^2 \frac{\partial x_2}{\partial q_2} + u_q^2 + u_Q^2 + a\Omega_2 = 0, \tag{12b}$$

where $\Omega_j = \left(\frac{\partial n_1}{\partial x_1}\frac{\partial x_1}{\partial q_j} + \frac{\partial n_1}{\partial x_1}\frac{\partial x_1}{\partial Q} + \frac{\partial n_1}{\partial x_2}\frac{\partial x_2}{\partial q_j} + \frac{\partial n_1}{\partial x_2}\frac{\partial x_2}{\partial Q} + \frac{\partial n_1}{\partial q_j} + \frac{\partial n_1}{\partial Q} \right), j = 1, 2.$ Combining (12a) with (12b) results in following conditions governing the allocations of the impure public good in regions 1 and 2, respectively:

$$n_1 \frac{u_q^1}{u_x^1} + n_1 \frac{u_Q^1}{u_x^1} = -n_1 \frac{\partial x_1}{\partial q_1} + \frac{an_1\Omega_1}{u_x^1}, \tag{13a}$$

$$n_2 \frac{u_q^2}{u_x^2} + n_2 \frac{u_Q^2}{u_x^2} = -n_2 \frac{\partial x_2}{\partial q_2} - \frac{an_2\Omega_2}{u_x^2}. \tag{13b}$$

Combining (13a) and (13b) yields a violation of (8) for the case of imperfect labor mobility. Thus, given our modelling assumptions the subgame perfect equilibria for the decentralized leadership game with an impure public good and imperfect labor mobility, where the central authority is only able to enact income redistribution across the regions, are *inefficient*.[13] This

[12] The sufficient second order conditions are similarly satisfied in the maximization problems of the first stage.

[13] Indeed, even in the face of perfect labor mobility (*a = 0*) any subgame perfect equilibrium with positive contributions is inefficient, i.e., equations (12a) and (12b) with *a = 0* still violate equation (8).

result follows from the fact that the egoistic components of the impure good are not fully internalized in each region prior to location decisions.

As in Cornes et al. (2008), assume that the central government can now make matching grants to each region on a per rate basis, denoted $m_j = \beta_j q_j$, $0 \leq \beta_j < 1$, $M = \sum_j m_j$, $j = 1,2$.[14] For future reference, let $p_j = q_j + m_j = (1+\beta_j)q_j$ and $P = \sum_j p_j$, $j=1,2$. The matching grants program is funded via lump-sum taxes to the central government, denoted c_j,, $\sum_j c_j = M$. Thus, the matching grants are restricted a priori to be budget-balancing. The aggregate resource constraint may now be rewritten as:

$$n_1 x_1 + n_2 x_2 + P = f^1(n_1) + f^2(n_2), \tag{14}$$

Similar to the previous game without matching grants, we consider a three-stage scenario whereby the regional governments, acting as Stackelberg leaders, pre-commit by selecting their contributions to the public good prior to the interregional income redistribution and matching grant policies of the central authority. The central authority determines its policies in the second stage of the game, after observing the public good contributions chosen by the regional governments and in anticipation of location choices made by residents. Residents make their location choices after they observe contributions to the public good, interregional redistributions of income, and matching grants.

The migration equilibrium condition with matching grants in now expressed as $u^1(x_1, p_1, P) + a(1 - n_1) = u^2(x_2, p_2, P) + an_1$, which, after substitution of (14) for x_1, may be re-expressed as:

$$u^1\left(\frac{f^1(n_1) + f^2(1-n_1) - (1-n_1)x_2 - P}{n_1}, p_1, P\right) + a\left(1-n_1\right) = u^2\left(x_2, p_2, P\right) + an_1. \tag{15}$$

[14] The following results are also obtained when block, or lump-sum matching grant subsidies are used by the central government. Note that in the presence of matching grants, positive interregional transfers (i.e., $\tau_j > 0$) can be thought of as countervailing penalties.

Equation (15) defines the implicit migration response functions:[15]

$$n_1 = n_1(x_2, p_1, p_2). \tag{16}$$

In the second stage, the central government chooses x_j and β_j, $j=1,2$ to maximize its utilitarian social welfare function. Note that when the central government chooses β_j,, each region's contribution to the public good is already pre-determined. Since the central government takes q_j as given and chooses β_j,, it ultimately determines p_j, $j=1,2$. To reiterate, this is not the same as the central government choosing q_j itself, since we assume an interior solution exists for the first stage of the game. Also, since we assume that $M = \sum_j c_j$, i.e., that the matching grants are budget balancing through lump-sum taxation and $\beta_j < 1$, $j = 1,2$, $M < Q$.

The problem faced by the central government in the second stage of the game is thus to choose $\{x_2, p_j\}_{j=1,2}$ to maximize:

$$\theta u^1\left(\frac{f_n^1(n_1) + f_n^2(1-n_1) - (1-n_1)x_2 - P}{n_1}, p_1, P\right) + (1-\theta)u^2\left(x_2, p_2, P\right), \tag{17}$$

subject to (17). As Appendix 3 shows, this problem yields conditions (6) and (7) directly, which implies (8). Since this result holds for any $a \geq 0$, it may be re-stated in the following proposition.

Proposition: For the decentralized leadership game with an impure public good and matching grants, any subgame perfect equilibrium with positive public-good contributions by each region is Pareto efficient regardless of the level at which residents are attached to regions.

The intuition behind Proposition 2 is as follows. First, the central authority's choice of x_j ensures the efficient population distribution by removing any incentives that residents might have in re-locating to obtain a higher income level. In other words, because they realize that the central authority's income redistribution policy has endogenized their responses, the residents have no better option than to distribute themselves efficiently across the two regions. Second, by

[15]The corresponding explicit functions, along with all other derivations for this section, are included in Appendix 3.

choosing its matching-grant policy *after* the regions' choices of public good provision, the central authority effectively controls the aggregate amount of the public good that will ultimately be produced. Similar to their choices of how to distribute themselves with respect to population, the regions therefore have no better option than to choose the efficient allocation of the public good, even though the public good provides 'impure' benefits. Thus, matching grants promote the correct incentives, and thereby induce the regions to equalize their private MRSs between the numeraire and public goods.[16]

From a policy perspective, this result has a clear implication: centrally provided matching grants (e.g., through the European Union's Structural and Cohesion Funds program), in concert with lump-sum income redistribution, is an effective policy tool in the face of regionally provided impure public goods as long as the grants are endogenously determined after the regional governments have made their public good allocations. In other words, timing matters.

This result is striking for yet another reason. Previous work by Boadway, et al. (1989) concluded that block-grant (i.e., lump-sum rather than percentage-based) matching grants are neutral, in that they leave unchanged the level of the public good in the new Nash equilibrium. Andreoni (1990) also found that block grants, funded by lump-sum taxation, are neutral for impure public goods. Only with per rate-based subsidies was he able to find non-neutrality. These results are therefore in direct contrast to ours. Not only are block grants non-neutral for our problem, but they are also capable of restoring Pareto efficiency in a federation with decentralized leadership, an impure public good, and imperfect labor mobility. Thus, we have

[16]The comparative static solutions behind our Proposition also yield additional insight into this general result. For the case of $M \neq 0$, $\partial M/\partial Q = -1$, $\partial c_j/\partial q_j = -1$, $\partial c_j/\partial q_{-j} = 0$, j=1,2. Thus, the central government's optimal matching grants policy reduces each region's lump-sum tax one-for-one for each additional unit of public good provision by the regions.

also found a corrective policy for the type of inefficiency first encountered by Wellisch (1994) in his model of a federation.

5. Conclusions

We have shown that in a federation such as the EU, characterized by decentralized leadership, an impure public good, and imperfect labor mobility, regional provision of the public good may be Pareto efficient and generally compatible with an interior solution for non-symmetrical regions. Our final Proposition, indeed, tells us that a decentralized leadership game, whereby regional governments pre-commit to contributions to an impure public good in anticipation of the center's interregional income and matching grant policies and subsequent labor mobility, has efficient subgame perfect equilibria as long as the regional governments provide positive amounts of the public good. This result does not depend on the regional attachment benefits derived by the residents of the federation.

This result extends several branches of the public goods literature. It extends the Wellisch (1994) and Caplan, et al. (2000) results to the case of impure public goods. It also extends the work on neutrality by Boadway, et al. (1989) and Andreoni (1989, 1990) by qualifying the role that a federation's structural hierarchy can play in 'neutralizing the effects of neutrality,' in terms of using matching grants in combination with lump-sum income redistribution to overcome the inability of the latter policy alone to induce an efficient provision of impure public goods in a decentralized leadership setting. By demonstrating the compatibility of an interior solution for the impure public goods case, we have also extended the work of Chiappori and Werning (2002). In particular, we have found a much broader class of public goods where their incompatibility result does not apply.

The standard assumption that all income generated within a region accrues only to residents of that region, on an equal per-capita basis, is employed here to derive all results. An interesting avenue for future work would be to consider situations whereby migrants retain possession of their non-human wealth when they move from one place to another, since this appears to be ubiquitous. In such an extension, migrants and non-migrants would typically be heterogeneous, a factor that may generate pecuniary externalities and diversity of incentives within regions. Our intuition, however, tells us that our main result would remain valid in this more complex setting, since the interregional policies of the center would induce the regional governments to adopt policies that maximize the federation's total income. Therefore, all externalities would be completely internalized and individual wealth levels would not be sensitive to migration decisions.

Appendix 1

The center chooses $\{x_1, x_2, q_1, q_2, n_1\}$ to maximize the Lagrangian:

$$\theta u^1\left(x_1,q_1,Q\right)+\left(1-\theta\right)u^2\left(x_2,q_2,Q\right)+\lambda\left(f^1(n_1)+f^2(n_2)-n_1x_1-n_2x_2-Q\right)$$

$$+\psi\left(u^1(x_1,q_1,Q)+a(1-n_1)-u^2(x_2,q_2,Q)-an_1\right).$$

The first-order conditions for this problem are:

$$\theta u_x^1-n_1\lambda+\Psi u_x^1=0, \tag{A1}$$

$$(1-\theta)u_x^2-n_2\lambda-\Psi u_x^2=0, \tag{A2}$$

$$\theta u_q^1+\theta u_Q^1+(1-\theta)u_Q^2-\lambda+\Psi\left(u_q^1+u_Q^1-u_Q^2\right)=0, \tag{A3}$$

$$\theta u_Q^1+(1-\theta)u_q^2+(1-\theta)u_Q^2-\lambda+\Psi\left(u_Q^1-u_q^2-u_Q^2\right)=0, \tag{A4}$$

$$\lambda\left(f_n^1 - f_n^2 - x_1 + x_2\right) - 2a\Psi = 0. \tag{A5}$$

Equations (A1) and (A2) imply

$$\frac{u_x^1}{n_1}(\theta + \Psi) = \frac{u_x^2}{n_2}\left(1 - \theta - \Psi\right). \tag{A6}$$

Successive substitution of (A1) into (A3), and then into (A6) results in (6) for region 1. Similar manipulations of (A2), (A4), and (A6) lead to (6) for region 2. Solving (A1) and (A2) for λ and Ψ yields, respectively,

$$\lambda = \frac{u_x^1 u_x^2}{n_2 u_x^1 + n_1 u_x^2}, \tag{A7}$$

$$\Psi = \frac{n_1(1-\theta)u_x^2 - n_2\theta u_x^1}{n_2 u_x^1 + n_1 u_x^2}. \tag{A8}$$

Substituting (A7) and (A8) into (A5) yields (7). □

Appendix 2

A straightforward exercise in comparative statics yields the following migration response functions from (3):

$$\frac{\partial n_1^2}{\partial x_1} = \frac{u_x^1}{2a} > 0, \tag{B1}$$

$$\frac{\partial n_1^2}{\partial x_2} = -\frac{u_x^2}{2a} < 0, \tag{B2}$$

$$\frac{\partial n_1^2}{\partial q_1} = \frac{u_q^1 + u_Q^1 - u_Q^2}{2a}, \tag{B3}$$

$$\frac{\partial n_1^2}{\partial q_2} = \frac{u_Q^1 - u_q^2 - u_Q^2}{2a}. \tag{B4}$$

Similarly, total differentiation of (5), accounting for (9), yields the following income-redistribution response functions:

$$\frac{\partial x_1}{\partial q_1} = -\frac{\left(\frac{u_q^1 + u_Q^1 - u_Q^2}{2a}\right)\left(x_1 - x_2 + f_n^2 - f_n^1\right) + 1}{\frac{u_x^1}{2a}\left(x_1 - x_2 + f_n^2 - f_n^1\right) + n_1}, \tag{B5}$$

$$\frac{\partial x_1}{\partial q_2} = -\frac{\left(\frac{u_Q^1 - u_q^2 - u_Q^2}{2a}\right)\left(x_1 - x_2 + f_n^2 - f_n^1\right) + 1}{\frac{u_x^1}{2a}\left(x_1 - x_2 + f_n^2 - f_n^1\right) + n_1}, \tag{B6}$$

$$\frac{\partial x_2}{\partial q_2} = -\frac{\left(\frac{u_Q^1 - u_q^2 - u_Q^2}{2a}\right)\left(x_1 - x_2 + f_n^2 - f_n^1\right) + 1}{-\frac{u_x^2}{2a}\left(x_1 - x_2 + f_n^2 - f_n^1\right) + n_2}, \tag{B7}$$

$$\frac{\partial x_2}{\partial q_1} = -\frac{\left(\frac{u_q^1 + u_Q^1 - u_Q^2}{2a}\right)\left(x_1 - x_2 + f_n^2 - f_n^1\right) + 1}{-\frac{u_x^2}{2a}\left(x_1 - x_2 + f_n^2 - f_n^1\right) + n_2}, \tag{B8}$$

$$\frac{\partial x_1}{\partial Q} = -\frac{\left(\frac{u_Q^1 - u_Q^2}{2a}\right)\left(x_1 - x_2 + f_n^2 - f_n^1\right) + 1}{\frac{u_x^1}{2a}\left(x_1 - x_2 + f_n^2 - f_n^1\right) + n_1}, \tag{B9}$$

$$\frac{\partial x_2}{\partial Q} = -\frac{\left(\frac{u_Q^1 - u_Q^2}{2a}\right)\left(x_1 - x_2 + f_n^2 - f_n^1\right) + 1}{-\frac{u_x^2}{2a}\left(x_1 - x_2 + f_n^2 - f_n^1\right) + n_2}. \tag{B10}$$

Substituting (B5) - (B10) into the expressions for Σ_j, $j=1,2$ proves that (13a) and (13b) result in a violation of (8). □

Appendix 3

A straightforward exercise in comparative statics yields the following migration response functions from (15):

$$\frac{\partial n_1}{\partial x_2} = \frac{n_2 u_x^1 + n_1 u_x^2}{D} < 0, \tag{C1}$$

$$\frac{\partial n_1}{\partial p_1} = \frac{u_x^1 + n_1 u_P^2 - n_1\left(u_p^1 + u_P^1\right)}{D}, \tag{C2}$$

$$\frac{\partial n_1}{\partial p_2} = \frac{u_x^1 - n_1 u_P^1 + n_1\left(u_p^2 + u_P^2\right)}{D}, \tag{C3}$$

where $D = u_x^1\left(f_n^1 - f_n^2 + x_2 - x_1\right) - 2an_1 < 0$ for a stable migration equilibrium. In the second stage, maximization of (17) with respect to $\{x_2, p_j\}_{j=1,2}$ and subject to (15) and (C1) - (C3) yields (6) and thus (8). □

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