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# Local autonomy and interregional equality

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# Local autonomy and interregional equality

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**Abstract**

This paper shows how two important interregional transfer schemes, the foundation grant and the power equalization grant scheme, can be seen as two different interpretations of equal opportunity ethics. It provides characterizations of both transfer schemes by the use of basic liberal egalitarian principles. Both the foundation grant and the power equalization grant scheme make use of specific reference levels. The paper also shows how reasonable requirements on the transfer schemes restrict the set of possible reference levels.

## 1 Introduction

Local jurisdictions within the same country often have different capacities for raising revenues and face different costs of providing public goods. This calls for intergovernmental transfers. Fiscal equalization aims at reconciling two important political principles in such situations. First, the *principle of fiscal capacity equalization*, saying that differences in the fiscal capacity among local jurisdiction should be eliminated. This principle reflects a concern with interregional inequality being a result of factors outside the control of the local jurisdictions. Second, the *principle of fiscal responsibility*, saying that the jurisdictions should be held responsible for decisions under their

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control, in particular their tax effort. This principle reflects a concern with local autonomy, where local tax discretion is seen as a way both of ensuring local democracy and of capturing decentralization gains. A challenge for the central government is thus to design a transfer scheme that satisfies both fundamental principles, that is, a transfer scheme that gives all local jurisdictions equal opportunities and at the same time holds them responsible for their decisions.

The equal opportunity approach has been predominant in the fiscal federalism literature (Boadway and Flatters (1982), Le Grand (1975, 1991), Ladd and Yinger (1994), Oakland (1994), and Mieszkovski and Musgrave (1999)). This predominance corresponds to a revival of liberal egalitarian, or equal opportunity, theories of justice in the philosophical and the welfare economics literature (Rawls (1971), Dworkin (1981), Sen (1985), Arneson (1989), Cohen (1993), Roemer (1993, 1996, 1998), Fleurbaey (1995a,b), Bossert and Fleurbaey (1996), Cappelen and Tungodden (2002, 2003) and Tungodden (2005)). Liberal egalitarian ethics in its most general form states that society should indemnify agents against poor outcomes that are the consequence of factors that are beyond their control, but not against outcomes that are the consequences of factors that are within their control (Roemer (1998)).

The liberal egalitarian view is considered to represent a much more appealing distributive ideal than strict (or outcome) egalitarianism. Strict egalitarians do not believe that there is a fairness argument for inequality, and argue that inequalities can only be justified in order to avoid Pareto inefficiency. Liberal egalitarians object to strict egalitarianism because they believe that *fairness* requires that agents should be held responsible for their choices. In this paper, we should like to focus on the nature of the fairness argument for allowing inequalities in local government revenues, and thus we will only briefly comment on the issue of incentive compatibility in the final section of the paper.

An inherent difficulty faced by liberal egalitarian theories is to determine which factors should be considered to be, respectively, within and beyond the control of the agents. In the context of fiscal equalization, this amounts to clarifying where the 'cut' should be drawn between the responsibilities of the central government and the responsibilities of the local governments. The literature on fiscal equalization generally assumes that the tax base, or the *fiscal capacity*, is outside the control of the local governments, whereas the tax rate, or *tax effort*, is considered within the control of the local government. We will adopt this assumption and thus do not pursue a further discussion of the basis for the assignment of local government responsibility. However, the reported results can easily be generalized to situations where, for example, the fiscal capacity partly is under the control of local governments and where local governments only have limited control over their tax effort.

In this paper, we show that the two prominent interregional transfer schemes, the *foundation grant* and the *power equalization grant*, satisfy two different interpretations of liberal egalitarian or equal opportunity ethics. More precisely, we establish that the difference between the foundation grant scheme and the power equalization grant scheme corresponds to a disagreement about how one should interpret the principle of fiscal capacity equalization and the principle of fiscal responsibility. The paper thus provides a normative justification for each of the two transfer schemes.

Both the foundation and the power equalization grant scheme make use of specific reference levels. The foundation grant scheme relies on a notion of a reference tax rate and the power equalization grant scheme on a notion of a reference jurisdiction. An important policy question is thus how these reference levels should be determined. In practice, this has to be decided in the political sphere, but we will show how various reasonable requirements on the transfer schemes restrict the set of possible reference levels.

The paper is organized as follows. In Section 2, we introduce the general model and the concept of fiscal capacity. Sections 3 and 4 analyze the foundation grant scheme and the power equalization scheme respectively, whereas Section 5 considers the problem of choosing reference levels. Section 6 concludes.

## 2 The fiscal capacity

Consider the following simple model with $N \geq 2$ local jurisdictions, where we assume that all jurisdictions are equally sized.[1] The revenues in jurisdiction $i$, $R_i$, are given by,

$$R_i(\mathbf{t},T) = t_i Y_i + T_i(\mathbf{t}), \tag{1}$$

where $Y_i$ is the tax base and $0 \leq t_i \leq 1$ is the tax rate of jurisdiction $i$, $T_i(\mathbf{t})$ is the transfer to jurisdiction $i$ within the intergovernmental transfer scheme

[1] It is straightforward to extend the model to a situation with jurisdictions of different size.

$T$ and given the vector of local taxes $\mathbf{t} = \langle t_1, ...., t_N \rangle$.

Each local government $i$ spends a certain amount, $B_i$, per capita on public services. Normalizing the population in each jurisdiction to unity, total expenditures can be written as,

$$B_i = G_i p_i, \tag{2}$$

where $G_i$ is the level of public services provided in jurisdiction $i$ and $p_i$ is the price level in the same jurisdiction. The budget constraint of a local government $i$ is given by,

$$B_i = R_i(\mathbf{t}, T) \tag{3}$$

Using the local government budget constraint (3) in (2), we can write the level of public services as a function of the vector of taxes,

$$G_i(\mathbf{t}, T) = \frac{R_i(\mathbf{t}, T)}{p_i}. \tag{4}$$

By assumption, the per capita tax base and the unit price of production are outside the control of the local government, whereas the tax rate can be set at their discretion. Let $T^0$ refer to the situation in which there are no intergovernmental transfers. In this case, the public service level is given by,

$$G_i(\mathbf{t}, T^0) = \frac{t_i Y_i}{p_i}. \tag{5}$$

We refer to $\frac{G_i(\mathbf{t}, T^0)}{t_i} = \frac{Y_i}{p_i}$ as the fiscal capacity of jurisdiction $i$. If all jurisdictions have the same fiscal capacity, then the liberal egalitarian perspective does not justify any redistribution. In general, however, we assume that there are at least two local jurisdictions $j$ and $k$ which differ in fiscal capacity.

We also assume that the central government does not have any external funds.[2] Any positive transfer to one jurisdiction, therefore, has to be financed by a negative transfer from other jurisdictions.

$$\sum T_i(\mathbf{t}) = 0. \tag{6}$$

As we will return to shortly, some standard grant formulas violate this condition. However, transfer schemes that do not satisfy the central government budget restriction (6), will result in a deficit that must be financed

[2] The model can easily be extended to the case where $\sum T_i(\mathbf{t}) = M$ for some $M \geq 0$.

by all the members of society. Consider for example a situation in which the deficit is financed by a proportional tax, $\tau$, levied by the central government on the total tax base in the country. In this situation, we have that $\sum T_i(\mathbf{t}) = \tau \sum Y_i$. The tax levied by the central government would be paid by tax payers residing in the local jurisdictions, where tax payers in jurisdiction $i$ would pay $\tau Y_i$. However, this can easily be rewritten as $\sum (T_i(\mathbf{t}) - \tau Y_i) = \sum T_i^*(\mathbf{t}) = 0$, where $T^*$ describes the net transfers from the central government. To simplify the discussion, but without loss of generality, we define transfers as the central government transfer net of taxes.

# 3 Foundation grants

A standard interpretation of the principle of fiscal equalization is that all jurisdictions choosing some reference tax level should be able to provide the same level of public services (Ladd and Yinger (1994)). Formally, this requirement can be stated as follows.

*Equal Provision for Reference Tax (EPRT): For any two local jurisdiction, $i$ and $j$, any reference tax level $t^R$, and any situation characterized by the tax vector $\mathbf{t}$, if $t_i = t_j = t^R$, then $G_i(\mathbf{t}, T) = G_j(\mathbf{t}, T)$.*

A standard interpretation of the principle of fiscal responsibility is that the local jurisdictions should be held accountable for the actual consequences of a change in their tax effort. Each jurisdiction thus should receive the marginal increase in revenue that follows from an increase in the local tax rate.

*Marginal Revenue Responsibility (MRR): For any jurisdiction $j$ and any two situations characterized by the tax vectors $\mathbf{t}$ and $\mathbf{t}^1$, where $t_j \neq t_j^1$ and $t_i = t_i^1$ for all $i \neq j$, $R_j(\mathbf{t}, T) - R_j(\mathbf{t}^1, T) = (t - t_j)Y_j$ and $R_i(\mathbf{t}, T) = R_i(\mathbf{t}^1, T), \forall i \neq j$.*

The *foundation grant scheme* is a prominent in the fiscal federalism literature and can be formalized as follows in the present framework.

$$T_i^F(\mathbf{t}) = p_i G^R - t^R Y_i, \tag{7}$$

where $G^R$ is the reference public service level and $t^R$ the reference tax rate. Given (7), the transfer assigned to each jurisdiction is determined independently of the local tax rate, and set so as to ensure that all jurisdictions choosing a reference tax rate $t^R$, are able to finance a reference public service level, $G^R$. Consequently, it follows straightforwardly that the foundation grant satisfies two interpretations of the principle of fiscal equalization and the principle of fiscal responsibility.

**Observation 1**. *The foundation grant scheme $T^F$ satisfies both Equal Provision for Reference Tax (EPRT) and Marginal Revenue Responsibility (MRR).*

The foundation grant scheme, as defined in (7), does not, however, satisfy the central government budget restriction (6), because $G^R$ and $t^R$ are determined independently of each other. In order to satisfy (6), the foundation grant scheme has to be based either on a reference level of public services *or* on a reference tax rate, as we will now show more formally.

Assume that we start by setting a reference tax rate $t^R$. This standard tax rate defines, together with the budget constraints at the local and at the national level, a unique public service level, $G^*$. Let us first aggregate the local budget constraints (3),

$$\sum p_i G^* = \sum (t^R Y_i + T_i^F(\mathbf{t})).$$

Rearranging we get,

$$G^* \sum p_i = t^R \sum Y_i + \sum T_i^F(\mathbf{t}).$$

Finally, by using (6), we find that,

$$G^* = t^R \frac{\bar{Y}}{\bar{p}}, \tag{8}$$

where $\bar{p} = \frac{\sum p_i}{N}$ and $\bar{Y} = \frac{\sum Y_i}{N}$. Substituting $G^*$ for $G^R$ in (7), we can establish the *balanced foundation grant* scheme,

$$T_i^{BF}(\mathbf{t}) = p_i G^* - t^R Y_i. \tag{9}$$

Alternatively, taking into account (8), it may be presented in the following way,

$$T_i^{BF}(\mathbf{t}) = t^R p_i (\frac{\bar{Y}}{\bar{p}} - \frac{Y_i}{p_i}). \tag{10}$$

From (10), we observe that local jurisdictions with a fiscal capacity below (above) the average fiscal capacity, $\frac{\bar{Y}}{\bar{p}}$, will receive positive (negative) transfers.

If we compare the balanced foundation grant scheme (10) with the foundation grant scheme (7), we note that it is no longer the absolute price level and the absolute tax base that determine the level of transfer. By taking into account the overall budget constraint in the economy, we see that the relevant parameters determining the size of the interregional transfer are the *relative* price level and the *relative* size of the tax base compared to other local jurisdictions.[3]

It turns out that the balanced foundation grant is the only class of transfer schemes that satisfies the requirement of equal provision for reference tax and the requirement of marginal reward responsibility.

**Proposition 1** *A balanced intergovernmental transfer scheme $T$ satisfies Equal Provision for Reference Tax (ERST) and Marginal Reward Responsibility (MRR) if and only if it is the balanced foundation grant $T^{BF}$.*[4]

**Proof.** See Appendix, Section 7.1. ■

Given that equal provision for reference tax and marginal revenue responsibility are common interpretations of the principle of fiscal capacity equalization and the principle of fiscal responsibility respectively, Proposition 1 should constitute an interesting normative justification of the balanced foundation grant scheme.

The requirement of equal provision for reference tax ensures equalization of fiscal capacity for a single reference tax level. But it allows for differences at all other levels of local taxation because each jurisdiction is held accountable

[3]The link between the foundation grant and the balanced foundation grant can be illustrated further by separating the balanced foundation grant into two parts. First, suppose that $G^R$ and $t^R$ were determined independently, that is, that everyone received a transfer determined by the foundation grant (7). This would have generated a deficit (or a surplus). Second, let this deficit (or surplus) be distributed among jurisdictions in a way that implies that jurisdictions choosing the reference tax rate $t^R$ attain the public service level $G^*$. Formally, we can do this by rewriting (10) in the following way, $T_i^{BF}(\mathbf{t}) = p_i G^R$ - $t^R Y_i$ - $p_i(G^R$ - $G^*)$.Using (8) and rearranging, we get, $T_i^{BF}(\mathbf{t}) = T_i^F(\mathbf{t})$ - $\frac{p_i}{\sum p_j} D(G^R, t^R)$, where $D(G^R, t^R) = \sum(p_j G^R$ - $t^R Y_j) = \sum T_i^F(\mathbf{t})$ is the total deficit (or surplus) generated by (7).

[4]See Bossert and Fleurbaey (1996) for a more general statement of the conditions ERST, MRR, and this result.

for the *actual* consequences of a change in its tax effort. However, since a jurisdiction's fiscal capacity is outside its control, it can be argued that the foundation grant violates the principle of equalization by holding jurisdictions responsible for too much. In other words, the foundation grant system may rely on too weak a concept of fiscal capacity equalization and too strong a concept of fiscal responsibility. We now turn to a transfer scheme that arguably avoids both these problems.

# 4 Power equalization grants

It has been argued that local governments should have the same opportunities, or power, to provide public goods and services for *all* levels of tax effort (Le Grand 1975, 1991). We can write this requirement as follows.

*Equal Provision for Equal Tax (EPET): For any two local jurisdictions $i$ and $j$ and any situation characterized by some tax vector $\mathbf{t}$, if $t_i = t_j$, then $G_i(\mathbf{t}, T) = G_j(\mathbf{t}, T)$.*

This requirement is a stronger, and arguably, a better interpretation of the principle of fiscal capacity equalization than the requirement of equal provision for reference tax. However, it turns out that EPET is incompatible with the requirement of marginal revenue responsibility, unless all jurisdictions have the same fiscal capacity.

**Proposition 2** *There exists no intergovernmental transfer scheme $T$ that satisfies Equal Provision for Equal Tax (EPET) and Marginal Revenue Responsibility (MRR).*[5]

**Proof.** See Appendix, Section 7.2. ■

If we give up marginal revenue responsibility, however, then there are many transfer schemes satisfying equal provision for equal tax. The most prominent in the fiscal federalism literature is the *power equalization grant.*

$$T_i^{PE}(\mathbf{t}) = t_i p_i (\frac{Y^R}{p^R} - \frac{Y_i}{p_i}), \tag{11}$$

where $\frac{Y^R}{p^R}$ represents the fiscal capacity of a reference jurisdiction, characterized by a reference tax base $Y^R$ and a reference price level $p^R$. The power

[5] See Bossert and Fleurbaey (1996) for a more general statement of EPET and this result.

equalization grant transfers resources so as to imitate a situation in which all local jurisdictions face the same reference tax base and the same references price level. In other words, the aim is to treat all jurisdictions *as if* they were identical with respect to those factors that are outside their control. Even though it is strongly egalitarian in nature, the power equalization grant should be clearly distinguished from the equalization of public goods provision as such. Different levels of public goods provision is compatible with fiscal capacity equalization, as long as these differences are a result of differences in tax effort and not of differences in fiscal capacity.

**Observation 2.** *The power equalization grant scheme $T^{PE}$ satisfies Equal Provision for Equal Tax (EPET) and allows for differences in public goods provision due to differences in tax effort among local jurisdictions.*

We can establish the observation formally by combining (1), (4), and (11), which gives us the difference in public goods provision between two jurisdictions.

$$G_j(\mathbf{t}, T^{PE}) - G_k(\mathbf{t}, T^{PE}) = (t_j - t_k)\frac{Y^R}{p^R}. \tag{12}$$

It follows straightforwardly from (12) that the power equalization grant scheme satisfies equal provision for equal taxes. Moreover, we also observe that there will be differences in local public goods provision if there are differences in the local tax rates (and the reference fiscal capacity is strictly positive).

However, there does not exist any reference fiscal capacity for which the power equalization grant scheme in (11) satisfies the central government budget constraint (6). In general, given (11), there will be a deficit or a surplus to be distributed among the local jurisdictions. By way of illustration, consider a situation where the central government budget balances. Suppose now that a jurisdiction $j$ with $\frac{Y_j}{p_j} < \frac{Y^R}{p^R}$ increases its tax rate. Given (11), the transfer to all the other jurisdictions should be the same. But this is not compatible with the transfer to $j$, where this jurisdiction is rewarded with more than the marginal increase in local tax revenues.

If we assume that any surplus or deficit is shared equally among the jurisdictions, then the *balanced power equalization grant* can be written as follows[6],

$$T_i^{BPE}(\mathbf{t}) = t_i p_i(\frac{Y^R}{p^R} - \frac{Y_i}{p_i}) - \frac{p_i}{\sum p_j}\sum t_j p_j(\frac{Y^R}{p^R} - \frac{Y_j}{p_j}). \qquad (15)$$

We will now provide a characterization of the balanced power equalization grant, where we assume that the reference fiscal capacity always is equal to the fiscal capacity of some local jurisdiction in the economy. Equal opportunity ethics involves treating jurisdictions *as if* they had the same fiscal capacity, and the reason why we accept that a jurisdiction's change of tax effort affects other jurisdictions is that we want to compensate for the fact that its fiscal capacity deviates from a certain reference standard. There is, however, no need to compensate the *reference jurisdiction* in this way. Hence, the reference jurisdiction should be held fully responsible for changes in marginal revenue following a change in the tax rate. Formally, we can state this as follows.

*No Effect of Reference Jurisdiction (NERJ): There exists some reference jurisdiction $r \in N$ such that for any two situations characterized by some tax vectors $\mathbf{t}$ and $\mathbf{t}^1$, where $t_i = t_i^1$ for all $i \neq r$,* $G_i(\mathbf{t}, T) = G_i(\mathbf{t}^1, T)$ for all *$i \neq r$.*

[6] To see how this formulation of the balanced power equalization grant can be derived from a more general formulation of the power equalization grant, consider what we name the *generalized power equalization grant* scheme.

$$T_i^{GPE}(\mathbf{t}) = t_i p_i(\frac{Y^R}{p^R} - \frac{Y_i}{p_i}) - g_i(\mathbf{t})\sum t_j p_j(\frac{Y^R}{p^R} - \frac{Y_j}{p_j}), \qquad (13)$$

where $\sum g_i(\mathbf{t}) = 1$. This version of the power equalization grant scheme satisfies (6), but it does not provide a specific rule for sharing the deficit or surplus among the local jurisdictions. However, in order to have the same reward structure as for the standard power equalization grant, as given by (12), we have to share the deficit or surplus equally among the local jurisdictions. In order to see this, notice first that

$$G_j(\mathbf{t}, T^{GPE}) \text{ - } G_k(\mathbf{t}, T^{GPE}) = (t_j - t_k)\frac{Y^R}{p^R} + (\frac{g_k(\mathbf{t})}{p_k} - \frac{g_j(\mathbf{t})}{p_j})\sum t_i p_i(\frac{Y^R}{p^R} - \frac{Y_i}{p_i}). \qquad (14)$$

By requiring $G_j(\mathbf{t}, T^{PE}) - G_k(\mathbf{t}, T^{PE}) = G_j(\mathbf{t}, T^{GPE}) - G_k(\mathbf{t}, T^{GPE})$, it follows from (12) and (14) that $\frac{g_k(\mathbf{t})}{p_k} = \frac{g_j(\mathbf{t})}{p_j}$. Hence, taking into account that $\sum g_i(\mathbf{t}) = 1$, we can establish that $g_j(\mathbf{t}) = \frac{p_j}{\sum p_i}$.

It turns out that the balanced power equalization grant is the only transfer scheme that satisfies both the requirement of no effect on reference jurisdiction and the requirement of equal provision for equal tax.

**Proposition 3** *A balanced intergovernmental transfer scheme $T$ satisfies Equal Provision for Equal Tax (EPET) and No Effect of Reference Jurisdiction (NERJ) if and only if it is the balanced power equalization grant $T^{BPE}$.*[7]

**Proof.** See Appendix, Section 7.3. ■

In other words, the balanced power equalization grant satisfies a strong interpretation of the principle of fiscal capacity equalization and a minimal interpretation of the principle of fiscal responsibility (saying that an increase in local tax effort at least should imply some increase in the overall local revenues). To what extent the local public service level will depend on local tax effort, however, is determined by the choice of reference fiscal capacity $\frac{Y^R}{p^R}$.

# 5 Determining the reference level

Both the balanced foundation grant and the balanced power equalization grant make use of specific reference levels. The balanced foundation grant applies a reference tax level and the balanced power equalization grant applies a reference fiscal capacity. The choice of reference level is important within both frameworks. In a balanced foundation grant system, a high reference tax level favours jurisdictions with a small tax base and a high price level, whereas a low reference tax level favours jurisdictions with a large tax base and a low price level. In a balanced power equalization grant system, a low reference fiscal capacity benefits the jurisdictions with a low tax rate, whereas a high reference fiscal capacity benefits the jurisdictions with a high tax rate. An important policy question is thus how these reference levels should be determined. In practice, this has to be decided in the political sphere, but we will show how various reasonable requirements on the transfer schemes restrict the set of possible reference levels.

[7] See Cappelen and Tungodden (2003) for a more informal dicsussion of a version of NERJ and this result.

## 5.1 No forced taxation

One fundamental intuition underlying the idea of local autonomy is that all jurisdictions should be free to choose whatever tax level they prefer. It could be argued that this freedom should include the freedom not to impose any local taxes. Formally this requirement can be captured by the following condition.

*No Forced Taxation (NFT): For any local jurisdiction j and any situation characterized by the tax vector* $\mathbf{t}$, *where* $t_j = 0$, $T_j \geq 0$.[8]

It turns out that this condition is extremely restrictive when it is imposed on a balanced foundation grant scheme. The only way a balanced foundation grant scheme can satisfy no forced taxation is by setting the reference tax rate equal to zero.

**Proposition 4** *A balanced foundation grant scheme* $T^{BF}$ *satisfies No Forced Taxation (NFT) if and only if the reference tax rate* $t^R = 0$.

**Proof.** See Appendix, Section 7.4 ■

Clearly, when the reference tax rate is equal to zero, there will be no redistribution. Any interesting version of the balanced foundation grant is thus incompatible with the requirement of no forced taxation.

Surprisingly, the no forced taxation requirement has very different implications when imposed on the balanced power equalization grant scheme. It turns out that a balanced power equalization grant only satisfies no forced taxation if the reference fiscal capacity is equal to or lower than the lowest fiscal capacity in the economy $(\frac{Y}{p})^{\min} = \min\left\{\frac{Y_1}{p_1}, ..., \frac{Y_N}{p_N}\right\}$.

**Proposition 5** *A balanced power equalization grant scheme* $T^{BPE}$ *satisfies No Forced Taxation (NFT) if and only if the reference fiscal capacity is equal to or lower than* $(\frac{Y}{p})^{\min}$.

**Proof.** See Appendix, Section 7.5. ■

A lower reference fiscal capacity does not in general imply more redistribution in a balanced power equalization grant system. In the limiting case, however, where the minimal fiscal capacity in the economy is equal to zero,

[8] See also Cappelen and Tungodden (2005) for a further analysis of NFL within the liberal egalitarian framework.

the balanced power equalization grant scheme can only satisfy no forced taxation by completely equalizing tax revenues between jurisdictions. Thus the requirement of no forced taxation pulls the two transfer schemes in opposite directions.

## 5.2 No dominance

An important ambition of a liberal egalitarian redistribution scheme is to equalize opportunities. Consequently, no jurisdiction should have an opportunity set that completely dominates the opportunity set of any other jurisdiction. We can write this requirement as follows.

*No Dominance (ND): There should not exist any two local jurisdictions $j$ and $k$, such that for every situation characterized by some tax vector $\mathbf{t}$, where $t_j = t_k > 0$, $G_j(\mathbf{t}, T) > G_k(\mathbf{t}, T)$.*

Within a balanced foundation grant scheme, no dominance will be satisfied if we impose a reference tax rate strictly above zero.

**Proposition 6** *A balanced foundation grant scheme $T^{BF}$ satisfies No Dominance (ND) if and only if the reference tax rate $t^R > 0$.*

**Proof.** See Appendix, Section 7.6. ■

It follows from Proposition 4 and Proposition 6 that it is impossible for a balanced foundation grant scheme to satisfy both no forced taxation and no dominance. This, however, is not the case for the balanced power equalization grant scheme. It is easily seen that the requirement of no dominance puts no restrictions on the choice of reference fiscal capacity.

**Proposition 7** *All balanced power equalization grant schemes $T^{BPE}$ satisfy No Dominance (ND).*

**Proof.** See Appendix, Section 7.7. ■

The fact that the no dominance requirement is only restrictive for the balanced foundation grant scheme, reflects that this scheme only satisfies a weak version of the principle of fiscal equalization, whereas the balanced power equalization grant scheme satisfies the strong version and equalizes local public service delivery for all levels of taxation.

## 5.3 Neutrality

A liberal egalitarian should also be neutral between different levels of local taxation. Hence, one should not consider a high local tax level (or high level of local public service delivery) as intrinsically better or worse than a low local tax level (or a low level of local public service delivery). How can we capture this intuition more precisely?

To formalize this idea, we introduce the concept of subgroups of jurisdictions. A group of jurisdictions $N^i = \{1^i, ...n^i\} \subset N$ constitute a subgroup of $N$ if and only if $(\frac{\sum_{i\in N^i} Y_i}{n^i})$=$(\frac{\sum_{i\in N} Y_i}{n})$ and $(\frac{\sum_{i\in N^i} p_i}{n^i})$=$(\frac{\sum_{i\in N} p_i}{n})$, which implies that the average fiscal capacity in a subgroup is the same as the average fiscal capacity in the economy. Consider now a situation in which the economy can be divided into two subgroups, where everyone is choosing a high tax rate in one of the subgroups and everyone is choosing a low tax rate in the other subgroup. We will argue that in this case, a transfer scheme is neutral between tax levels if and only if it does not imply a net transfer between the two subgroups. More formally, this requirement can be stated as follows.

*Neutrality Between Tax Effort Levels (NBTEL): If there exist m subgroups, $N^1, ..., N^m$, where $\cup_{i=1,.,,m} N^i = N$, then for any situation characterized by some tax vector* $\mathbf{t}$, where $t_{1^i} = ... = t_{n^i}$ *for every* $N^i$, $N^i = N^1, ..., N^m$, $\sum_{i\in N^1} T_i(\mathbf{t}) = ... = \sum_{i\in N^m} T_i(\mathbf{t}) = 0.$

It turns out that all balanced foundation grant schemes satisfy this requirement.

**Proposition 8** *All balanced foundation grant schemes $T^{BF}$ satisfy Neutrality Between Tax Effort Levels (NBTEL).*

**Proof.** See Appendix, Section 7.8. ■

The underlying intuition is simply that a balanced foundation grant scheme is neutral among effort levels because the transfer received by any jurisdiction is independent of the local tax rate.

Given that the transfers in a balanced power equalization grant scheme depend on local tax effort, one might think that all versions of a balanced power equalization grant violate the neutrality condition. But this is not the case. It turns out that there is one, but only one, reference level that ensures neutrality.

**Proposition 9** *A balanced power equalization grant scheme, $T^{BPE}$, satisfies Neutrality Between Tax Effort Levels (NBTEL) if and only if the reference fiscal capacity is equal to $(\frac{\bar{Y}}{\bar{p}})$.*

**Proof.** See Appendix, Section 7.9. ■

If the reference fiscal capacity is higher (lower) than the average fiscal capacity, then there will be a net transfer from (to) a subgroup with a high tax rate to (from) a subgroup with a low tax rate. The only way of avoiding any such net transfers between subgroups (when all jurisdictions in each of the subgroups exercise the same level of effort), is to have the average fiscal capacity as the reference standard. Taking into account Proposition 5, this shows that there is no balanced power equalization grant that satisfies both no forced taxation and neutrality.

# 6 Concluding remarks

There is a tension between the ideal of local autonomy and interregional equality. In this paper, we have argued that two important interregional grant formulas, the foundation grant and the power equalization grant, can be seen as two different ways of resolving this tension. Using different interpretations of the principle of fiscal capacity equalization and the principle of fiscal responsibility, we have characterized both the balanced foundation grant scheme and the balanced power equalization grant scheme. The foundation grant scheme satisfies a weak interpretation of the principle of fiscal capacity equalization, the *equal provision for reference tax* requirement, and a strong interpretation of the principle of fiscal responsibility, the *marginal revenue responsibility* requirement. The power equalization grant scheme, on the other hand, satisfies a stronger interpretation of the principle of fiscal capacity equalization, the requirement of *equal provision for equal tax*, and a weaker interpretation of the principle of responsibility.

Both transfer schemes rely on the choice of reference levels, namely a reference tax in the balanced foundation grant and a reference fiscal capacity in the balanced power equalization grant. We have also analyzed how three reasonable requirements on the transfer schemes restrict the choice of such reference levels. First, we established that the requirement of no forced taxation has opposite effects on the two transfer schemes; it implies no redistribution within the balanced foundation grant scheme, whereas it implies a high degree of equalization within the balanced power equalization scheme. Second, we established that the requirement of no dominance of opportunity sets does not limit the choice of reference fiscal capacity within the balanced power equalization grant, but it implies that the references tax rate under the balanced foundation grant should be positive. Consequently, it is impossible for any balanced foundation grant to satisfy both no forced taxation and no dominance. Finally, we showed that all balanced foundation grant schemes satisfy a neutrality requirement saying that no level of local taxation (or public service delivery) should be considered intrinsically better than any other local level of taxation. The power equalization grant, however, only satisfies this requirement if the reference fiscal capacity is equal to the average fiscal capacity, which implies that no balanced power equalization grant satisfies both no forced taxation and neutrality.

The focus of this paper has been on the nature of the fairness argument for allowing inequalities in local government revenues, and hence we have not studied the incentive properties of the two grant formulas. Clearly, a foundation grant scheme is fully incentive compatible, given that each jurisdiction is rewarded with its marginal revenue, while a power equalization scheme may cause an efficiency loss (depending on the structure of the preferences of the local jurisdictions). In sum, if we consider the power equalization grant to be a fairer interregional transfer scheme, then in general there will be a trade-off between efficiency and fairness considerations.

# 7 Appendix

## 7.1 Proof of Proposition 1

Let us first prove the if part of the proposition.

(i) To see that $T^{BF}$ satisfies ERST for any $t^R$, consider any situation characterized by some tax vector $\mathbf{t}$, where for some local jurisdictions $j, k$, $t_j = t_k = t^R$. By combining (10) and (4), it follows that $G_j(\mathbf{t}, T^{BF}) = G_k(\mathbf{t}, T^{BF}) = t^R \frac{\bar{Y}}{\bar{p}}$.

(ii) To see that $T^{BF}$ satisfies MRR for any $t^R$, consider any two situation characterized by the tax vectors $\mathbf{t}$,$\mathbf{t}^1$, where for some local jurisdiction $j$, $t_j \neq t_j^1$ and $t_i = t_i^1$ for all $i \neq j$. By (10), $T_i^{BF}(\mathbf{t}) = T_i^{BF}(\mathbf{t}^1)$ for all $i$. Hence, by (1), $R_i(\mathbf{t}, T^{BF}) = R_i(\mathbf{t}^1, T^{BF})$ for all $i \neq j$ and $R_j(\mathbf{t}, T^{BF})$ - $R_j(\mathbf{t}^1, T^{BF}) = (t_j - t_j^1)Y_i$.

We will now prove the only-if part of the proposition.

(iii) Consider a situation characterized by $\mathbf{t}^R$, in which all local jurisdictions have chosen the reference tax rate, $t^R$. From ERST, $G_i(\mathbf{t}^R, T) = G_j(\mathbf{t}^R, T)$ for all jurisdictions $i$. From (10), we know that the transfer to each jurisdiction in this case is given by $T_i(\mathbf{t}^R) = t^R \bar{Y}(\frac{p_i}{\bar{p}} - \frac{Y_i}{\bar{Y}})$.

(iv) We will now prove that for any situation characterized by $\mathbf{t}$, $T_i(\mathbf{t}) = T_i(\mathbf{t}^R) = T_i^{BF}(\mathbf{t})$ for all $i$. Consider first a situation characterized by $\mathbf{t}^1$, where for some $k$, $t_i^1 = t^R, \forall i \neq k$ and $t_k^1 = t_k$. From MRR, we know that $R_i(\mathbf{t}^R, T) - R_i(\mathbf{t}^1, T) = 0, \forall i \neq k$. This implies, using (6), that $T_i(\mathbf{t}^1) = T_i(\mathbf{t}^R)$ for all $i$.

(v) By repeating (iv) for each $i \neq k$, we get that $T_i(\mathbf{t}) = T_i(\mathbf{t}^R) = T_i^{BF}(\mathbf{t})$ for all $i$. The result follows.

## 7.2 Proof of Proposition 2

The proof relies on the assumption that there exist two jurisdictions, $j$ and $k$, with different fiscal capacity, i.e., $\frac{Y_j}{pj} \neq \frac{Y_k}{p_k}$.

(i) Consider a situation characterized by some tax vector $\mathbf{t}$, in which all local jurisdictions have chosen the same tax rate. By EPET, $G_i(\mathbf{t}, T) = G_j(\mathbf{t}, T)$ for all jurisdictions $i$.

(ii) Consider now a situation characterized by a tax vector $\mathbf{t}^1$, where $t_i^1 = t_i$, for all $i \neq j$ and $t_j^1 \neq t_j$. By MRR, $R_i(\mathbf{t}, T) - R_i(\mathbf{t}^1, T) = 0$ for all $i \neq j$. From (1) and (6), we have that $R_j(\mathbf{t}^1, T) - R_j(\mathbf{t}, T) = (t_j^1 - t_j)Y_j$. By (1) and (4), $G_i(\mathbf{t}^1, T)) = G_i(\mathbf{t}, T))$for all $i \neq j$, and $G_j(\mathbf{t}^1, T) - G_j(\mathbf{t}, T) = \frac{(t_j^1 - t_j)Y_j}{p_j}$.

(iii) Finally, consider a situation characterized by the tax vector $\mathbf{t}^2$, where $t_i^2 = t_i^1$, for all $i \neq k$ and $t_k^2 = t_j^1$. From the same reasoning as in (ii), it follows that $G_i(\mathbf{t}^2, T) = G_i(\mathbf{t}^1, T)$, for all $i \neq k$, and $G_k(\mathbf{t}^2, T) - G_k(\mathbf{t}^1, T) = \frac{(t_k^2 - t_k^1)Y_k}{p_k}$. By the fact that $(t_j^1 - t_j) = (t_k^2 - t_k^1)$, it follows that $G_k(\mathbf{t}^2, T) - G_k(\mathbf{t}^1, T) = \frac{(t_j^1 - t_j)Y_k}{p_k}$.

(iv) By (ii) and (iii), $G_j(\mathbf{t}^2, T) = G_j(\mathbf{t}, T) + \frac{(t_j^1 - t_j)Y_j}{p_j}$ and $G_k(\mathbf{t}^2, T) = G_k(\mathbf{t}, T) + \frac{(t_j^1 - t_j)Y_k}{p_k}$. By (i), $G_j(\mathbf{t}, T) = G_k(\mathbf{t}, T)$. By assumption, $\frac{Y_j}{pj} \neq \frac{Y_k}{pk}$, and thus $\frac{(t_j^1 - t_j)Y_j}{p_j} \neq \frac{(t_j^1 - t_j)Y_k}{p_k}$. Hence, $G_j(\mathbf{t}^2, T) \neq G_k(\mathbf{t}^2, T)$. But this violates EPET, and the result follows.

## 7.3 Proof of Proposition 3

Let us first prove the if part of the proposition.

(i) To see that $T^{BPE}$ satisfies EPET for any reference jurisdiction $r$, consider any situation characterized by some tax vector $\mathbf{t}$, where $t_j = t_k = t$ for some local jurisdictions $j, k$. By combining (15) and (4), it follows that $G_j(\mathbf{t}, T^{BPE}) = G_k(\mathbf{t}, T^{BPE}) = \frac{Y^R}{p^R}\frac{t}{\sum p_i} - \sum t_i p_i(\frac{Y^R}{p^R} - \frac{Y_i}{p_i})$.

(ii) To see that $T^{BPE}$ satisfies NERJ for any reference jurisdiction $r$, consider any two situations characterized by some tax vectors $\mathbf{t}$,$\mathbf{t}^1$, where $t_i = t_i^1$ for all $i \neq r$. By combining (15) and (4), it follows that $G_j(\mathbf{t}, T^{BPE}) - G_j(\mathbf{t}^1, T^{BPE}) = \frac{1}{\sum p_i}(\sum t_i^1 p_i(\frac{Y^R}{p^R} - \frac{Y_i}{p_i}) - \sum t_i p_i(\frac{Y^R}{p^R} - \frac{Y_i}{p_i}))$. By the fact that $t_i = t_i^1$ for all $i \neq r$, it follows that $t_i^1 p_i(\frac{Y^R}{p^R} - \frac{Y_i}{p_i}) = t_i p_i(\frac{Y^R}{p^R} - \frac{Y_i}{p_i}))$ for all $i \neq r$. By the fact that $r$ is the reference jurisdiction, it follows that $t_r^1 p_i(\frac{Y^R}{p^R} - \frac{Y_r}{p_r}) = t_r p_i(\frac{Y^R}{p^R} - \frac{Y_r}{p_r}) = 0$. Taking together, this implies that $G_j(\mathbf{t}, T^{BPE}) - G_j(\mathbf{t}^1, T^{BPE}) = 0$.

We will now prove the only-if part of the proposition.

(iii) By (15) and (4), it follows that $G_j(\mathbf{t}, T^{BPE}) - G_k(\mathbf{t}, T^{BPE}) = (t_j - t_k)\frac{Y^R}{p^R}$. Suppose that there exists some transfer scheme $T$ different from $T^{BPE}$ satisfying EPET and NERJ. This implies that for some jurisdictions $j$ and $k$ and some situation characterized by some tax vector $\mathbf{t}$, $G_k(\mathbf{t}, T) - G_j(\mathbf{t}, T) \neq (t_k - t_j)\frac{Y^R}{p^R}$. It follows from the fact that $T$ satisfies EPET that $t_k \neq t_j$, which we thus assume in the rest of the proof.

(iv) Consider a situation characterized by $\mathbf{t}^1$, where $t_i^1 = t_i$ for all $i \neq r$ and $t_r^1 = t_j$, where $r$ is the reference jurisdiction. By EPET, $G_r(\mathbf{t}^1, T) = G_j(\mathbf{t}^1, T)$ and by NERJ, $G_i(\mathbf{t}^1, T) = G_i(\mathbf{t}, T)$, for all $i \neq r$. Hence, we have that $G_r(\mathbf{t}^1, T) = G_j(\mathbf{t}, T)$.

(v) Consider a situation characterized by $\mathbf{t}^2$, where $t_i^2 = t_i^1$, for all $i \neq r$ and $t_r^2 = t_k$. By EPET and the fact that $t_2^k = t_k$, $G_r(\mathbf{t}^2, T) = G_k(\mathbf{t}^2, T)$ and by NERJ, $G_i(\mathbf{t}^2, T) = G_i(\mathbf{t}^1, T)$, for all $i \neq l$. Hence, also taking into account (iv), $G_r(\mathbf{t}^2, T) = G_k(\mathbf{t}, T)$.

(vi) By (iv), (v) and (6), we then have that $G_r(\mathbf{t}^2, T) - G_r(\mathbf{t}^1, T) = (t_r^2 - t_r^1)\frac{Y^R}{p^R}$. Given that $t_r^2 = t_k^2 = t_k$ and $t_r^1 = t_j^1 = t_j$, it follows that $G_r(\mathbf{t}^2, T) - G_r(\mathbf{t}^1, T) = (t_k - t_j)\frac{Y^R}{p^R}$.

(vii) From (iv) and (v), we have that $G_r(\mathbf{t}^1, T) = G_j(\mathbf{t}, T)$ and $G_r(\mathbf{t}^2, T) = G_k(\mathbf{t}, T)$. Thus, given (vi), it follows that $G_k(\mathbf{t}, T) - G_j(\mathbf{t}, T) = (t_k - t_j)\frac{Y^R}{p^R}$. Hence, the supposition in (iii) is not possible.

(viii) Given (vii) and taking into account (1) and (4), we have that for any $\mathbf{t}$ and any two local jurisdiction $j$ and $i$, $G_j(\mathbf{t}, T) - G_i(\mathbf{t}, T) = \frac{t_j Y_j + T_j(\mathbf{t})}{p_j} - \frac{t_i Y_i + T_i(\mathbf{t})}{p_i} = (t_j - t_i)\frac{Y^R}{p^R}$. Hence, by rearranging and comparing jurisdiction $j$ with all local jurisdictions $i = 1, ..., N$, we have that $\sum_i [p_i \frac{t_j Y_j + T_j(\mathbf{t})}{p_j}$ - $(t_i Y_i + T_i(\mathbf{t}))] = \sum_i [p_i (t_j - t_i)\frac{Y^R}{p^R}]$. By taking into account (6) and simplifying, we find that $T_j(\mathbf{t}) = t_j p_j (\frac{Y^R}{p^R} - \frac{Y_j}{pj}) - \frac{p_j}{\sum p_i} \sum t_i p_i (\frac{Y^R}{p^R} - \frac{Y_i}{p_i})$. The result follows.

## 7.4 Proof of Proposition 4

The if part of this proposition is trivial and hence we will only prove the only-if part.

(i) By assumption, there exists a local jurisdiction $j$ such that $\frac{\bar{Y}}{\bar{p}} > \frac{Y_j}{p_j}$. Consider any situation characterized by a tax vector $\mathbf{t}$, where $t_i = 0$ for all $i \neq j$ and $t_j > 0$.

(ii) By (10), $T_j^{BF}(\mathbf{t}) > 0$ for any $t^R > 0$. By NFT, $T_i^{BF}(\mathbf{t}) \geq 0$ for all $i \neq j$. But given (6), this is not possible. The result follows.

## 7.5 Proof of Proposition 5

The if part.

(i) Consider any jurisdiction $j$ and any situation characterized by some tax vector $\mathbf{t}$, where $t_j = 0$. It follows from (15) that $T_j^{BPE}(\mathbf{t}) = -\frac{p_j}{\sum p_i} \sum t_i p_i (\frac{Y^R}{p^R} - \frac{Y_i}{p_i})$. It follows that $T_j^{BPE}(\mathbf{t}) \geq 0$ if $\frac{Y^R}{p^R} \leq (\frac{Y}{p})^{\min}$.

The only-if part.

(ii) Consider some jurisdiction $j$ and any tax vector $\mathbf{t}$, where $\frac{Y_j}{p_j} = (\frac{Y}{p})^{\min}$, $t_j > 0$, and $t_i = 0$ for all $i \neq j$. By (15), $T_k^{BPE}(\mathbf{t}) = -\frac{p_k}{\sum p_i} \sum t_i p_i (\frac{Y^R}{p^R} - \frac{Y_i}{p_i})$ for all $k \neq j$. But this implies that if $\frac{Y^R}{p^R} > (\frac{Y}{p})^{\min}$, then $T_k^{BPE}(\mathbf{t}) < 0$ for all $k \neq j$.However, this violates NFT and the result follows.

## 7.6 Proof of Proposition 6

The only-if part of this proposition is trivial and hence we will only prove the if part.

(i) By combining (1), (4), and (10), it follows that for every $\mathbf{t}$, $G_i(\mathbf{t}, T^{BF}) = (t_i - t^R)\frac{Y_i}{p_i} + t^R \frac{\bar{Y}}{\bar{p}}$.

(ii) Consider any two local jurisdictions $j$ and $k$. If $\frac{Y_j}{p_j} = \frac{Y_k}{Y_k}$, then it follows straightforwardly from (i) that for every $\mathbf{t}$, where $t_j = t_k$, $G_j(\mathbf{t}, T^{BF}) = G_k(\mathbf{t}, T^{BF})$.

(iii) Consider the case where $\frac{Y_j}{p_j} > \frac{Y_k}{Y_k}$. Given that $t^R > 0$, it follows that there exist $\mathbf{t}$ and $\mathbf{t}^1$, where $t_j = t_k < t^R$ and $t_j = t_k > t^R$. By (i), it follows that $G_j(\mathbf{t}, T^{BF}) < G_k(\mathbf{t}, T^{BF})$ and $G_j(\mathbf{t}^1, T^{BF}) > G_k(\mathbf{t}^1, T^{BF})$. The result follows.

## 7.7 Proof of Proposition 7

Consider any two jurisdictions $j, k$ and any situation characterized by some tax vector $\mathbf{t}$, where $t_j = t_k > 0$. By (1), (4), and (15), $G_j(\mathbf{t}, T^{BPE}) - G_k(\mathbf{t}, T^{BPE}) = (t_j - t_k)\frac{Y^R}{p^R} = 0$, and the result follows.

## 7.8 Proof of Proposition 8

Consider any subgroup $N^m$ and situation characterized by some tax vector $\mathbf{t}$, where $t_{1^m} = ... = t_{n^m}$. By (10), we have that $\sum\limits_{i \in N^m} T_i^m(\mathbf{t}) = \sum\limits_{i \in N^m} t^R p_i(\frac{\bar{Y}}{\bar{p}} - \frac{Y_i}{p_i}) = t^R(\sum\limits_{i \in N^m} p_i \frac{\bar{Y}}{\bar{p}} - \sum\limits_{i \in N^m} Y_i)$. By the definition of a subgroup, we know that $\sum\limits_{i \in N^m} \frac{p_i}{n^m} = \bar{p}$ and $\sum\limits_{i \in N^m} \frac{Y_i}{n^m} = \bar{Y}$. Hence, it follows that $\sum\limits_{i \in N^m} T_i^m(\mathbf{t}) = 0$.

## 7.9 Proof of Proposition 9

The proof relies on the assumption that there exist m subgroups, $N^1, ..., N^m$, where $\cup_{i=1,.,,m} N^i = N$.

We will first prove the if part of the proposition.

(i) Consider any situation characterized by some tax vector $\mathbf{t}$, where $t_{1^i} = ... = t_{N^i}$ for every $N^i$, $N^i = N^1, ..., N^m$. By (15), it follows that for any subgroup $N^i$, $\sum_{i \in N^i} T_i^{BPE}(\mathbf{t}) = \sum_{i \in N^i}[t_i p_i(\frac{Y^R}{p^R}$ - $\frac{Y_i}{p_i})$ - $\frac{p_i}{\sum_{j \in N} p_j}$ $\sum_{j \in N} t_j p_j(\frac{Y^R}{p^R}$ - $\frac{Y_j}{p_j})]$.

(ii) Let us first consider the first term in $\sum_{i \in N^i} T_i^{BPE}(\mathbf{t})$, as given in (i). If $\frac{Y^R}{p^R} = \frac{\bar{Y}}{\bar{p}}$ and $t_{1^i} = ... = t_{n^i} = t^*$, then $\sum_{i \in N^i} t_i p_i(\frac{Y^R}{p^R} - \frac{Y_i}{p_i}) = \sum_{i \in N^i} t^* p_i(\frac{\bar{Y}}{\bar{p}} - \frac{Y_i}{p_i})$ $= t^* \sum_{i \in N^i} p_i(\frac{\bar{Y}}{\bar{p}} - \frac{\sum_{i \in N^i} Y_i}{\sum_{i \in N^i} p_i}) = 0$.

(iii) Consider now the second part of the second term in $\sum_{i\in N^i} T_i^{BPE}(\mathbf{t})$, as given in (i), that is $\sum_{j\in N} t_j p_j(\frac{Y^R}{p^R} - \frac{Y_j}{p_j})$. Given the assumption that there exist $m$ subgroups, $N^1, ..., N^m$, where $\cup_{i=1,.,,m} N^i = N$, it follows straightforwardly that we can write $\sum_{j\in N} t_j \ p_j(\frac{Y^R}{p^R} - \frac{Y_j}{p_j})] \ = \sum_{i=N^1}^{N^m} \sum_{j\in i} t_j p_j(\frac{Y^R}{p^R} - \frac{Y_j}{p_j})]$. By the same line of reasoning as in (ii), we can show that for every $i = N^1, ..., N^m$, $\sum_{j\in i} t_j p_j(\frac{Y^R}{p^R} - \frac{Y_j}{p_j})] = 0$.

(iv) In sum, taking together (ii) and (iii), we have established that $\sum_{i\in N^i} T_i^{BPE}(\mathbf{t}) = 0$, and the result follows.

We will now prove the only-if part.

(v) Consider any situation where we have $m$ subgroups, $N^1, ..., N^m$, where $\cup_{i=1,.,,m} N^i = N$, and some tax vector $\mathbf{t}$, where $t_{1^i} = ... = t_{n^i}$ for every $N^i$, $N^i = N^1, ..., N^m$. Consider any two subgroups $j$ and $k$, where $t_{1^j} = ... = t_{n^j} = t$, $t_{1^k} = ... = t_{n^k} = t^1$, and $t > t^1$. By (i) and the definition of subgroups (where $\frac{\sum_{i\in N^j} Y_i}{\sum_{i\in N^j} p_i} = \frac{\sum_{i\in N^k} Y_i}{\sum_{i\in N^k} p_i} = (\frac{\bar{Y}}{\bar{p}})$ and $\frac{\sum_{i\in N^j} p_i}{n^j} = \frac{\sum_{i\in N^j} p_i}{n^k} = \bar{p}$), it follows from (15) that $\sum_{i\in N^j} T_i^{BPE}(\mathbf{t}) - \sum_{i\in N^k} T_i^{BPE}(\mathbf{t}) = (t - t^1)\bar{p}(\frac{Y^R}{p^R} - \frac{\bar{Y}}{\bar{p}}) > 0$. This violates NBTEL if $\frac{Y^R}{p^R} \neq \frac{\bar{Y}}{\bar{p}}$, and the result follows.

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