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Fiscal equalisation and the induced under-taxation of economic rent

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Abstract

The point of this paper is to show that under a certain set of highly plausible circumstances, the well-known fiscal equalisation transfer required to establish spatial efficiency in federations, regional unions of states (such as the EU) or unitary countries with local governments, induces under-taxation of economic rents. The circumstances which lead to this result are carefully explained in the paper. It is also noted that the result does not invalidate the standard spatial efficiency case for inter-regional transfers. Rather, it means that whether such transfers are welfare enhancing in net terms depends on the benefit from achieving spatial efficiency relative to the cost arising from the under-taxation of rent.

Key Words: federalism, intergovernmental relations, inter-governmental differentials and their effects, federal state relations.

JEL: H73, H77.

1 Introduction

The fiscal federalism literature shows us that spatial efficiency in federations, unitary nations with local governments or regional unions of semi-independent nation states, may require an inter-regional equalization transfer to correct for fiscal and economic rent externalities arising from population mobility. This is known as the efficiency-in-migration efficiency case for equalization. A full survey of the relevant literature is beyond the scope of this paper. An excellent overview discussion is provided in Boadway (2004).

To achieve spatial efficiency, the equalization transfer must redistribute income from regions that generate relatively large rents in favour of low rent regions. Region-specific economic rents can arise from the presence of fixed factors such as natural resources or

land. The efficient transfer must also redistribute income from regions with relatively small fiscal externalities in favour of those with comparatively large fiscal externalities. There is a well-known expression for the optimal transfer which captures these externalities formally. Absent equalization, free migration equilibria in this world are inefficient.

Economic rents generated by fixed factors affect migration decisions and the equalization transfer only if they are captured (socialized) by regional governments through their budget and disbursed to residents as higher spending on services and/or lower taxes. If they are not socialized and remain as private income, or get capitalized, rents have no effect on the efficiency of migration equilibria. In this case, the efficiency-in-migration case for equalization depends on fiscal externalities. Hence, the local capture and disbursement of rents on the basis of residency is a critical part of the efficiency-in-migration case for inter-regional equalization transfers.

The theory has abstracted from the precise mechanism through which rents are socialized. This has helped researchers to focus on other important and interesting issues. Nevertheless, it does imply that the theory is incomplete in the sense that it has not considering inter-regional transfers in a context where regions also choose rent capture effort as a voluntary choice based on optimizing behavior.

A question this raises is whether we can learn anything new about the efficiency-in-migration case for equalization if the extent of rent capture by regions is a decision variable, such as a rent tax?

The purpose of this paper is to provide a formal answer to this question. It does so by developing a fairly standard policy game for an economy with regions. These regions can be thought of as states or provinces in a federation, semi-independent nation-states within a regional union (such as the EU) or local governments in a unitary country. The provision of local public goods is assumed to be a regional decision variable, a central authority chooses an equalization transfer designed to correct for fiscal and rent externalities and regions pre-commit to their policies as first movers. As is carefully explained in the paper, this set up corresponds to the assignment of decision variables and timing frequently observed in practice and is studied in the literature. It is, therefore, an important case to consider. A point of departure in this paper is that regions can also tax rent generated from a fixed factor, the revenue from which is redistributed on the basis of residency. Regions choose the tax to maximize their own self interest.

From the equilibrium conditions for this model, it is shown that the presence of a central equalization scheme designed to achieve spatial efficiency causes regions to undertax economic rents. What is more, there is the distinct possibility that regions will choose to leave all local rents as private income; that is, rent tax rates in equilibrium are equal to zero. Thus, while the equalization transfer still ensures that equilibria are spatially

efficient, at least under the assumptions about timing and assignment made in this paper, it does so at the cost of causing under-taxation of economic rents with a consequent loss of national social welfare (since positive taxes on rent are shown to be welfare enhancing).

Thus, allowing rent capture to be a decision variable for regions who pursue their own self-interest tells us something substantially new about the efficiency-in-migration case for inter-regional transfers. It has been thought such transfers were unambiguously welfare enhancing. Once rent capture is endogenous, this is no longer necessarily so clear cut, at least for the assignment and timing considered in this paper. When rent taxation is a voluntary regional choice, in order to find out whether equalization that corrects for fiscal and rent externalities is unambiguously welfare enhancing, we really need to consider how the social welfare costs of rent under-taxation offset the social welfare gain from achieving spatial efficiency. In other words, once the induced side effects of rent under-taxation are recognized, one should be interested in the net welfare effect of transfers designed to establish spatial efficiency.

Hence, the paper identifies a plausible set of circumstances which lead us to modify our thinking on the efficiency-in-migration case for inter-regional equalization transfers.

The paper structure is as follows. Section 2 sets out the basic model of a decentralized economy where rent capture is an optimizing decision. This model is employed throughout the paper. As a benchmark, Section 3 then solves a social planner problem for this economy to find the conditions that must be satisfied for efficiency (including a description of the optimal rent taxes). In Section 4, a three stage policy game is developed where regions choose rent taxes as anticipatory first movers while an inter-regional transfer is chosen by a central authority. Interpretation and discussion of extensions is provided in Section 5 while conclusions are in Section 6.

2 Model

Consider a regional economy with two regions indexed by $i = 1, 2$. The economy could be a federation, regional union of semi-independent nation states, or a unitary country with local jurisdictions. There is a given population, N, of imperfectly mobile citizens each endowed with a unit of labor which they supply within their region of residence. Hence, from now on N is also the national labor supply. Setting this equal to one for convenience, the total labor supply is $n_1 + n_2 = 1$ where n_1 and n_2 are the regional supplies of labor. Given that labor is mobile, from the perspective of regions labor supply is a variable input. Region i also has a fixed factor, T_i which is thought of as a natural resource owned by the residents of region i. Regions can have different endowments of the fixed factor.

Each region uses the variable labor and fixed input to produce a numeraire, $f_i(n_i, T_i)$,

where $f_i(n_i, T_i)$ is continuous, strictly increasing and strictly quasi-concave on $\mathbb{R}^+_n$ and $f_i(0,0) = 0$. Assuming the numeraire has a price of one, $f_i(n_i, T_i)$ is also the value of output in region i. Since T_i is fixed, output of the numeraire is expressed as $f_i(n_i)$ from now on. The price of labor in region i (wage) is equal to its marginal product as follows:

$$w_i = \frac{\partial f_i(n_i)}{\partial n_i} \qquad i = 1, 2. \tag{2.1}$$

It is also supposed that there is diminishing marginal product of labor and hence that $\frac{\partial w_i}{\partial n_i} < 0$.

Region i has a large and fixed number, $j_i = 1, ..., J_i$, of identical firms who each produce an equal per firm share, $\frac{f_i(n_i)}{J_i}$, of the region's numeraire. Once firms have paid labor its wage, on the assumption that T_i has no market price, the region's economic rent,

$$\pi_i = f_i(n_i) - w_i n_i \qquad i = 1, 2, \tag{2.2}$$

accrues to the firms of region i as super-normal profits. Since firms in region i are identical they each earn the same share of this profit, $\frac{\pi_i}{J_i}$.

At this point, the most general approach would be to allow firms in region i to be owned by residents of region i and j ($i \neq j$) and foreigners. This can be done by assuming given ownership shares using parameters. An advantage of this option is that it allows for an initial allocation of rents as private income across the two regions and between the economy and foreign shareholders. However, this makes the modeling of the optimal rent tax levied by a region, to be examined below, more complex in the sense that it introduces cross border rent tax externalities. To abstract from these complexities, the simplifying assumption is made here that all firms in the economy are foreign-owned and hence that rents or profits accrue in the first instance to foreign shareholders.

Region i also has a government which levies a source-based tax, t_i, where $0 \leqslant t_i \leqslant 1$, on economic rent in region i. As will be shown, the tax choice is made as part of an optimizing decision. Revenue collected from the tax is $t_i \pi_i$ and the net profit accruing to foreign shareholders is $(1 - t_i)\pi_i$. Once captured, rent in region i is recycled to local residents as an equal per capita lump sum transfer through the regional budget. Thus, through a combination of a rent tax and revenue recycling, private rent is turned into income which is then collectively owned by the locals of region i.

If $t_i = 0$, there is no local rent capture effort. Alternatively, if $t_i = 1$ the rent in region i is fully appropriated by regional governments. A tax rate between zero and one implies that regions socialize some of their rents and let a portion flow offshore as foreign profit income.

Since the fixed factor has no market price the rent tax can also be interpreted as an

attempt by region i to provide a rental rate or shadow price, $\frac{t_i\pi_i}{T_i}$, for each unit of the fixed input used by firms. The regional government, rather than the market, sets the price for the fixed factor by way of its rent tax policy.[1]

With this set up, total labor income in region i consists of wage income, $w_i n_i$, together with revenue raised from the rent tax, $t_i\pi_i$, which is recycled to them on an equal per capita lump sum basis.[2] Hence, total labor income is defined as $w_i n_i + t_i\pi_i$. Within each region, $\frac{w_i n_i + t_i\pi_i}{n_i}$ is per capita labor income. Mobile labor is assumed to have identical quasi-linear preferences. The analysis can, therefore, proceed in terms of a representative citizen who has a continuous utility function which is linear in x_i, a pure private good, and strictly concave in g_i, a local public good benefit, as follows,

$$u_i = x_i + v_i(g_i) \qquad i = 1, 2, \tag{2.3}$$

where $v_i(g_i)$ is the sub-utility function for g_i. For simplicity, private and local public good prices are assumed to be given and equal to one.

Public good output and the benefit received by households are linked by the relationship

$$g_i = \frac{G_i}{n_i^\alpha} \qquad i = 1, 2, \tag{2.4}$$

where α is a congestion parameter assumed to be the same across regions. If $\alpha = 0$, then $g_i = G_i$ and region i provides a pure local public good while if $\alpha = 1$ we have $g_i = \frac{G_i}{n_i}$ and region i provides a pure private good. For alpha between zero and one the public good is mixed.

Mobility with attachment to place, as in Mansoorian and Myers (1993), implies the following migration constraint must also be satisfied,

$$x_1 + v_1(g_1) + a(1 - n_1) = x_2 + v_2(g_2) + an_2, \tag{2.5}$$

where $0 \leqslant a \leqslant 1$ is the attachment parameter. Noting from (2.4) that $G_i = n_i^\alpha g_i$ is total spending on the local public good in region i the budget constraint for region i is

$$x_i n_i + n_i^\alpha g_i = w_i n_i + t_i\pi_i \qquad i = 1, 2. \tag{2.6}$$

This completes the set up of the basic model. Its salient points are as follows. A given

[1] In practice, regional governments use a number of taxes to extract super-normal profit or rent from firms involved in the extraction of fixed factors such as natural resources. Such taxes include user fees/charges, licenses and royalties based on the value of production. The rent tax, t_i, in this model can be seen as a simple proxy for these taxes.

[2] If $t_i = 1$, labor income is $f(n_i)$ and per capita income is simply the average product, $\frac{f_i(n_i)}{n_i}$.

number of citizens migrate imperfectly between two regions. Together with a region-specific fixed factor (natural resources), mobile labor is used in each region to produce a numeraire which is converted into a private and congested local public good. Labor is paid its wage (marginal product) but the fixed input has no market price to firms. Economic rent generated from its use initially accrues to foreigners as private income but can be captured by regional governments through a rent tax. The quantum of rent harvested is the result of an optimizing decision by regions, explained below. The rent tax can also be seen as regions providing a rental price for the fixed natural resource input. Revenue from the tax is recycled to residents of region i lump sum, and equal per capita.

3 Social welfare optimum

The objective of this section is to define the conditions that must be satisfied in the economy described above for a social welfare optimum. These conditions are then used as a benchmark to assess the efficiency of decentralized outcomes where regions choose rent taxes in the presence of inter-regional equalization transfers. The social welfare optimum is characterized in the standard way by solving the problem of a mythical central planner who chooses x_i, g_i, t_i and n_1 to maximize the social welfare function,

$$W = \delta u_1 + (1-\delta)u_2, \tag{3.1}$$

subject to the following migration and aggregate feasibility constraints,

$$(i) \quad x_1 + v_1(g_1) + a(1-n_1) = x_2 + v_2(g_2) + an_2$$

$$(ii) \;\; n_1 x_1 + (1-n_1)x_2 + n_1^{\alpha} g_1 + (1-n_1)^{\alpha} g_2 = w_1 n_1 + t_1 \pi_1 + w_2(1-n_1) + t_2 \pi_2,$$

where $n_2 = 1 - n_1$ is used in the aggregate feasibility constraint, *(ii)*, and $n_2 = 1 - n_1$ is used in π_2. The parameter $0 \leqslant \delta \leqslant 1$ is the weight allocated to region 1 in the social welfare function and $(1-\delta)$ is the weight for region 2.

The first order necessary conditions are,

$$\begin{aligned}
(x_1): &\quad \delta + \lambda_1 - \lambda_2 n_1 = 0 \\
(g_1): &\quad (\delta + \lambda_1) v_{1,g_1} - \lambda_2 n_1^{\alpha} = 0 \\
(x_2): &\quad 1 - \delta + \lambda_1 - \lambda_2 n_2 = 0 \\
(g_2): &\quad (1 - \delta + \lambda_1) v_{2,g_2} - \lambda_2 n_2^{\alpha} = 0
\end{aligned}$$

$$
\begin{aligned}
(n_1): \quad & -2a\lambda_1 + \lambda_2(\mu_1 - \mu_2) = 0 \\
(t_1): \quad & \pi_1 = 0 \\
(t_2): \quad & \pi_2 = 0,
\end{aligned} \tag{3.2}
$$

where the variables in brackets preceding each expression represent the decision variable being optimized. Note that

$$
\mu_1 = \left\{ (w_1 - x_1) - \alpha \frac{G_1}{n_1} - (1 - t_1) \frac{\partial \pi_1}{\partial n_1} \right\}
$$

and

$$
\mu_2 = \left\{ (w_2 - x_2) - \alpha \frac{G_2}{n_2} - (1 - t_2) \frac{\partial \pi_2}{\partial n_2} \right\}, \tag{3.3}
$$

which appear in the first order condition for n_1, are the social marginal benefits of an additional migrant in regions 1 and 2 respectively. Observe also from (2.2) that

$$
\frac{\partial \pi_i}{\partial n_i} = -\frac{\partial w_i}{\partial n_i} n_i \qquad i = 1, 2 \tag{3.4}
$$

is the change in aggregate rent income in region i as a migrant enters the region. With diminishing marginal product of labor, $\frac{\partial \pi_i}{\partial n_i} = -\frac{\partial w_i}{\partial n_i} n_i > 0$ and total rent in region i is increasing in labor supply.

Combining the first order conditions for x_1, g_1, x_2 and g_2 yields,

$$
n_i^{1-\alpha} v_{i,g_i} = 1 \qquad i = 1, 2. \tag{3.5}
$$

We can see from this that optimality requires local public goods to be provided according to the usual Samuelson efficiency rule. This is not new and is not discussed further.

Solving for λ_1 and λ_2 from the first order conditions for x_1 and x_2, and using the solutions in the first order condition for n_1 while allowing δ to vary from 0 to 1, the first order necessary condition for n_1 can be expressed as

$$
-2an_2 \leqslant (\mu_1 - \mu_2) \leqslant 2an_1. \tag{3.6}
$$

This is analogous to the standard condition for spatial efficiency [see expressions (16) and (17) in Mansoorian and Myers (1993), equation (7) in Wellisch (1994) or expression (26) in Caplan et al. (2000)]. It too is not explained further.

Now consider the first order condition for t_1 from (3.2). π_1 is the marginal benefit to region 1 residents from an increase in t_1. Optimality requires the planner to choose t_1 so that this marginal benefit is equal to zero. Given that initially rents accrue to

foreigners by assumption, the burden of the tax is borne only by them. The welfare of foreigners does not enter into the planner's social welfare function so she increases the tax until marginal benefit is driven to zero (there is no marginal cost). An analogous interpretation applies to the first order necessary condition for t_2. Namely, the planner increases t_2 until the marginal benefit in terms of additional rent revenue is zero.[3] Thus, the rent tax first order conditions imply that $t_1 = t_2 = 1$ and locally generated economic rent is fully captured for the benefit of locals.[4]

This result is consistent with proposition 1, page 237, of Wildasin and Wilson (1998) who also find it optimal for a region to levy a 100 percent tax on rents from a fixed factor (land in their model) which would otherwise accrue to foreigners. It is an example of tax exporting: the burden of the tax is fully borne by shareholders who do not appear in the planner's social welfare function. With this initial assignment of rent income, the tax has no marginal cost from the perspective of a social planner.

This completes the discussion of a social optimum. The key points are as follows. A welfare optimum requires efficient public good provision and spatial efficiency - as is well-known - and also that all economic rent is captured and recycled to locals. A confiscatory rent tax also provides a shadow price for the underlying fixed factor, natural resources. Full rent capture is optimal here because all rents accrue to foreigners, by assumption, and the social planner does not care about their well-being in her social welfare function.

4 Regional policy game

Let us now consider a three stage policy game in which regions choose rent taxes and local public good provision as first movers. An inter-regional equalisation transfer which corrects for fiscal and rent externalities arising from migration is chosen in a second stage by a central authority for given regional policies. Labor makes its location choice last based on what it observes regional and central policies to be. It is assumed regions anticipate the induced migration and transfer effects of their policies and the central authority takes regional policies as given while anticipating the induced effects of its policies on labor location choices.

Why focus on this assignment of decision variables and order of moves? Assigning

[3]The total effect on regional rent of a change in the rent tax, t_1, is actually $\frac{\partial \pi_1}{\partial t_1} = \pi_1 + t_1 \frac{d\pi_1}{dn_1}\frac{\partial n_1}{\partial t_1}$. However, from (2.2) rent in region 1 is a function of the region's labor supply and in the planner problem labor supply is a choice variable. Hence, when the planner chooses t_1 it does so for a given n_1 implying that $\frac{\partial n_1}{\partial t_1} = 0$. This is why the change in rent for region 1 as the planner increases t_1 is just π_1. This is in contrast to the policy game considered below where t_1 is a choice variable. There, n_1 is a function of joint local and central policies, including t_1. One must then take account of the impact of a change in the rent tax on labor supply and hence the level of rent itself; that is, the $t_1 \frac{d\pi_1}{dn_1}\frac{\partial n_1}{\partial t_1}$ term is non-zero.

[4]When $t_i = 1$, the planner ensures a rental rate of $\frac{\pi_i}{T_i}$ is charged for the fixed input.

the transfer centrally corresponds with the practice of equalisation world-wide where inter-regional transfers are usually implemented by a national treasury or other central institution. For example, in Australia an independent federal commission implements equalisation between states. The equalization transfer in any given year is also commonly based on historical regional spending and tax data. In the Australian case, the transfer in any particular year is derived from a moving average of state spending and tax data for the previous three years.[5] This provides Australian states with the opportunity to act pre-emptively and distort policies to influence their transfer (see Petchey (2009)). It is also the case that in many economies regions levy taxes designed to capture supernormal profits or rents obtained by firms from fixed factors, and that there are no constitutional or other restrictions to stop regions from taxing rents. So regional assignment of rent taxes is also plausible and a reflection of the reality of tax assignment.

Perhaps this is also why this assignment and timing of moves has been considered formally in the fiscal federalism literature (though not specifically the assignment of rent taxes locally). Some notable papers here include Caplan et al. (2000), Boadway et al. (2003) and Boadway and Tremblay (2010). Drawing on the industrial organisation literature, Caplan et al. (2000) think of this in terms of regions as Stackleberg leaders.

To be more specific, suppose regions choose t_i and g_i, for $i = 1, 2$, to maximize region-specific social welfare. A central authority chooses a self-financing lump sum transfer, ρ, which it makes from region 1 to 2, in order to maximize national social welfare. When $\rho > 0$, the transfer redistributes income from region 1 to 2 and if $\rho < 0$ the opposite applies; the transfer takes income from region 2 and gives it to region 1. Mobile labor makes its location choices in the final stage for given regional and central policies. In stage 1, regions also anticipate the labor location and equalization transfer responses to their policy choices. Similarly, in stage 2 the central authority anticipates migration responses to its transfer choice and takes regional policies as given.

With this arrangement, the vector of decision variables for region i is $s_i = \{g_i, t_i\}$ while for both regions it is $s = \{s_i, s_j\}$ where $i = 1, 2$ and $i \neq j$. The vector, $S = \{s, \rho\}$, denotes the decision variables for the whole economy.

The solution to the game is a sub-game perfect Nash equilibrium solved using backward induction. It turns out that to obtain all the information required for the results we need to solve each stage. However, for the first stage one need only focus on the problem of region 1, as the solution for region 2 is analogous. Also, there is no need to provide a formal solution to the sub-game perfect equilibrium as the results can be obtained without going this far.

Before proceeding, it is useful to set out the regional feasible conditions and the migra-

[5]See Commonwealth Grants Commission (2015) and in particular pages 27-35 for explanation.

tion constraint under the above assignment of decision variables. The feasible constraint for region 1 is

$$x_1 n_1 + n_1^{\alpha} g_1 = w_1 n_1 + t_1 \pi_1 - \rho. \tag{4.1}$$

Using $n_2 = (1 - n_1)$ from (2.1), the feasible constraint for region 2, inclusive of the equalization transfer, can be expressed in terms of n_1 as follows,

$$x_2(1 - n_1) + (1 - n_1)^{\alpha} g_2 = w_1(1 - n_1) + t_1 \pi_2 + \rho, \tag{4.2}$$

where $\pi_2 = f_2(1-n_1) - w_2(1-n_1)$. From these feasible constraints, an expression can be derived for per capita private good consumption in each region. This allows the migration constraint defined at (2.5) to be expressed as

$$\begin{aligned} \left\{ \frac{w_1 n_1 + t_1 \pi_1 - \rho - n_1^{\alpha} g_1}{n_1} \right\} + v_1(g_1) + a(1 - n_1) = \\ \left\{ \frac{w_2(1 - n_1) + t_2 \pi_2 + \rho - (1 - n_1)^{\alpha} g_2}{1 - n_1} \right\} + v_2(g_2) + a n_1 \end{aligned} \tag{4.3}$$

From this constraint, implicitly, n_1 is a function of the regional economy's vector of decision variables, that is,

$$n_1 = n_1(S). \tag{4.4}$$

Since $n_2 = 1 - n_1$, then n_2 is also, implicitly, a function of the economy's decision variables; thus define $n_2(S)$. The implication is that the spatial distribution of labor is determined entirely by regional and central policies.

4.1 Stage 3: Migration equilibrium

The following discussion examines in some detail the migration decision taken by labor in the final stage. The rationale for doing this is that the conditions for existence and stability of a migration equilibrium provide restrictions which are important in explaining the relationship between equalization and rent capture by regions. It is useful to start this discussion by noticing that once the game between regions and the central authority is played and their policies, S^*, chosen, labor makes its location choice given these policies, consistent with the migration constraint. This decision process manifests itself as a solution, $n_1(S^*)$, to (4.4) which yields the labor supply to region 1 (and hence region 2). Together, these labor supplies constitute a migration equilibrium.

This raises an issue which is useful for us to explore, namely, under what conditions will a unique, stable, solution, $n_1^*(S^*)$, and hence $n_2(S^*)$, exist? The answer begins by observing from the regional and central maximization problems to be developed below

that the per capita maximum value function for a representative citizen of region i is

$$V_i(n_i) = \underset{S^*}{Max}\, u_i \qquad i = 1, 2. \tag{4.5}$$

The maximum value function, $V_i(n_i)$, yields per capita utility in region i as a function of n_i for a given S^*. From the envelope theorem[6],

$$\frac{dV_i(n_i)}{dn_i} = \frac{du_i}{dn_i} = \frac{dx_i}{dn_i} = \frac{\mu_i}{n_i}, \tag{4.6}$$

Further, using the approach in Wildasin (1986)[7], one can show that x_i is strictly concave in n_i. Therefore, over a range of labor supply values from 0 to n_i^*, where n_i^* is the region's optimal population at which per capita private good consumption and indirect utility are maximized, we have $\frac{dx_i}{dn_i} > 0$. For this range of values for n_i the region is under-populated. At the optimal population, $\frac{dx_i}{dn_i} = 0$ and per capita consumption, as well as indirect utility, are at maximum. When the region's labor supply exceeds n_i^* we have $\frac{dx_i}{dn_i} < 0$ and per capita private good consumption (and hence indirect utility) are decreasing in n_i. For this range of n_i values, the region is over-populated in the sense that its per capita private good consumption and hence indirect utility decrease with more migrants. Given that $\frac{dx_i}{dn_i} = \frac{\mu_i}{n_i}$ from (4.6), this also means that μ_i, the social marginal benefit of adding labor supply to region i, has the following signs: (i) $\mu_i > 0$ when $\frac{dx_i}{dn_i} > 0$ (under-population); $\mu_i = 0$ when $\frac{dx_i}{dn_i} = 0$ (optimal population); and (iii) $\mu_i < 0$ when $\frac{dx_i}{dn_i} < 0$ (over-population).

Strict concavity of x_i in n_i means the following also holds,

$$\frac{d^2x_i}{dn_i^2} = \frac{1}{n_i}\left\{\frac{d\mu_i}{dn_i} - \frac{dx_i}{dn_i}\right\} < 0 \qquad i = 1, 2. \tag{4.7}$$

This, in turn, implies that

$$\frac{d\mu_i}{dn_i} < \frac{dx_i}{dn_i} = \frac{\mu_i}{n_i} \qquad i = 1, 2 \tag{4.8}$$

must also be satisfied.

From Boadway and Flatters (1982), migration equilibria are more likely to be stable in over-populated federations where $\frac{dx_i}{dn_i} < 0$ and hence $\mu_i < 0$. If this restriction is adopted, combined with the strict concavity of x_i in n_i, we are more likely to be assured of the existence of a unique, stable, migration equilibrium, for given regional and central policies.

[6] As Milleron (1977) has shown, an envelope condition holds in these models if there is strong complementary between the public and private good. In this case, one can find a maximum for u_i at S^* by varying n_i to maximize per capita private good consumption, x_i.

[7] See pages 22 to 28 and in particular diagram 3 on page 26 in Wildasin (1986).

This, in turn, implies from (4.8) that

$$\frac{d\mu_i}{dn_i} < 0 \qquad i = 1, 2. \tag{4.9}$$

Thus, if social marginal benefit in region i is negative *and* decreasing in n_i one is more likely to have existence of a stable migration equilibrium. As will be shown below, these existence and stability restrictions are important in helping to determine how equalization affects regional rent capture efforts, hence their explanation above.

4.2 Stage 2: Inter-regional transfer

In stage 2, the central authority chooses the inter-regional transfer to maximize social welfare for the economy. Specifically, the authority solves

$$\begin{aligned} \underset{\rho}{Max} \;\; W = \delta \left\{ \frac{w_1 n_1 + t_1 \pi_1 - \rho - n_1^{\alpha} g_1}{n_1} + v_1(g_1) \right\} + \\ (1-\delta) \left\{ \frac{w_2(1-n_1) + t_2 \pi_2 + \rho - (1-n_1)^{\alpha} g_2}{1-n_1} + v_2(g_2) \right\}, \end{aligned} \tag{4.10}$$

subject to (4.3) where δ and $(1-\delta)$ are the weights for regions 1 and 2 respectively in the social welfare function. The authority takes regional policies chosen in stage 1 as given and anticipates the migration response to its choice of transfer. Given this, the first order necessary condition for ρ is,

$$(\rho): \quad \frac{\partial n_1}{\partial \rho} \left\{ \frac{\delta}{n_1}\mu_1 - \frac{(1-\delta)}{n_2}\mu_2 \right\} - \frac{\delta}{n_1} + \frac{(1-\delta)}{n_2} = 0, \tag{4.11}$$

where μ_1 and μ_2 are the social marginal benefits defined at (3.3). From the migration constraint, the central authority's perceived response for labor supply in region 1 to an increment in the equalization transfer is

$$\frac{\partial n_1}{\partial \rho} = \frac{A}{D} < 0, \tag{4.12}$$

where

$$A = \left\{ \frac{1}{n_1} + \frac{1}{n_2} \right\} > 0; \qquad D = \left\{ \frac{\mu_1}{n_1} + \frac{\mu_2}{n_2} - 2 \right\} < 0.$$

Note that D is negative because stability requires $\mu_i < 0$ for $i = 1, 2$. In view of this, and given that A is positive, $\frac{\partial n_1}{\partial \rho}$ is negative. As the central authority increases the transfer from region 1 to 2, labor migrates in favour of region 2 (and vice versa).

Combining (4.11) and (4.12), the first order condition for the inter-regional equaliza-

tion transfer, ρ, can be expressed as,

$$(\rho): \qquad F = \mu_1 - \mu_2 - 2a\left\{(1-\delta)n_1 - \delta(1-n_1)\right\} = 0. \tag{4.13}$$

The central authority will choose a value for ρ which satisfies this condition for given regional rent taxes and local public good provision. Since the authority's first order condition for ρ is equivalent to (3.6), one can conclude that the inter-regional equalizing transfer establishes an efficient migration equilibrium (spatial efficiency) for any given regional policies.

4.3 Stage 1: Regional rent taxes and public goods

In stage 1 of the policy game region 1 solves:

$$\underset{(t_1,g_1)}{Max}\, u_1 = \left\{\frac{w_1 n_1 + t_1\pi_1 - \rho - n_1^{\alpha} g_1}{n_1}\right\} + v_1(g_1), \tag{4.14}$$

subject to (4.3) while taking the policies of region 2 as given. The first order necessary condition for t_1 is,

$$(t_1): \quad \mu_1\frac{\partial n_1}{\partial t_1} - \frac{\partial \rho}{\partial t_1} + \pi_1 = 0. \tag{4.15}$$

The following discussion derives expressions for the labor supply and equalization responses, $\frac{\partial n_1}{\partial t_1}$ and $\frac{\partial \rho}{\partial t_1}$. Once signed, these expressions allow one to explain how region 1 chooses the rent tax in the presence of an anticipated equalization transfer. The first step is to differentiate the migration constraint with respect to t_1. After rearrangement, this yields the following expression,

$$D\frac{\partial n_1}{\partial t_1} - A\frac{\partial \rho}{\partial t_1} = -\frac{\pi_1}{n_1}. \tag{4.16}$$

From the first order condition for the equalization transfer, (4.13), it is also possible to obtain the equalization transfer response to an increment in the rent tax. The implicit function theorem tells us this is

$$\frac{\partial \rho}{\partial t_1} = -\frac{F_{t_1}}{F_\rho}. \tag{4.17}$$

Obtaining the partial derivatives, F_{t_1} and F_ρ, from the first order condition for the transfer, using them in the above and rearranging yields the following expression,

$$\frac{\partial \rho}{\partial t_1} A\left\{\frac{H}{D} + 2\right\} + H\frac{\partial n_1}{\partial t_1} = \left\{\frac{\pi_1}{n_1} - \frac{\partial \pi_1}{\partial n_1}\right\} \tag{4.18}$$

where

$$H = \left\{ \frac{\partial \mu_1}{\partial n_1} + \frac{\partial \mu_2}{\partial n_2} \right\} < 0.$$

Note that H is negative because $\partial \mu_1 / \partial n_1$ and $\partial \mu_2 / \partial n_2$ must each be negative if we are to be assured of the existence of a stable and unique migration equilibrium (see earlier discussion of stage 3).

The expressions at (4.16) and (4.18) have two unknowns, $\frac{\partial n_1}{\partial t_1}$ and $\frac{\partial \rho}{\partial t_1}$. Solving simultaneously yields:

$$\frac{\partial n_1}{\partial t_1} = \frac{-\left\{ \frac{\pi_1}{n_1} \left(\frac{H}{D} + 1 \right) + \frac{\partial \pi_1}{\partial n_1} \right\}}{2(H + D)} > 0 \tag{4.19}$$

and

$$\frac{\partial \rho}{\partial t_1} = \frac{D \left\{ \frac{\pi_1}{n_1} - \frac{\partial \pi_1}{\partial n_1} \right\} + H \frac{\pi_1}{n_1}}{2A(H + D)}. \tag{4.20}$$

The restrictions sufficient for existence and stability of a migration equilibrium discussed earlier are now useful in signing these responses. As discussed in Section 4.1, existence and stability require that $\mu_i < 0$ and $\frac{\partial \mu_i}{\partial n_i} < 0$ for $i = 1, 2$. From the definition of H at (4.18), $\frac{\partial \mu_i}{\partial n_i} < 0$ implies that $H < 0$. Moreover, if $\mu_i < 0$ then D, defined at (4.12), is negative. This implies that the sign of the labor supply response is unambiguously positive; that is, $\frac{\partial n_1}{\partial t_1} > 0$. Thus, as region 1 increases its rent tax, and hence rent capture, it attracts mobile labor from the other region.

Even with the restrictions imposed by existence and stability, the sign of the equalization transfer response to an increase in the rent tax is more difficult to determine. It depends on whether the term $(\frac{\pi_1}{n_1} - \frac{\partial \pi_1}{\partial n_1})$ in (4.20) is positive or negative. If negative, the sign of $\frac{\partial \rho}{\partial t_1}$ is still ambiguous. However, if $(\frac{\pi_1}{n_1} - \frac{\partial \pi_1}{\partial n_1})$ is positive, then $\frac{\partial \rho}{\partial t_1}$ is unambiguously positive: a higher rent tax in region 1 results in a larger ρ, or transfer from region 1 to 2.

Certainly, it is feasible for $(\frac{\pi_1}{n_1} - \frac{\partial \pi_1}{\partial n_1})$ to be positive. All this requires is that the per capita rent consumed by a marginal migrant to region 1 is greater than the positive rent income externality they confer; namely, that $\frac{\pi_1}{n_1} > \frac{\partial \pi_1}{\partial n_1}$. This, in turn, ensures that per capita rent is decreasing in labor supply. It is feasible that a migration equilibrium to stage 1, and a sub-game perfect equilibrium to the game, exists in which this is true. However, it has not been possible to show that it holds generally, so one must admit the possibility that it does not[8].

Proceeding with the argument on the basis that $\frac{\pi_1}{n_1} > \frac{\partial \pi_1}{\partial n_1}$ and hence $\frac{\partial \rho}{\partial t_1} > 0$, any increase in rent capture effort by region 1 will increase the equalization transfer it makes

[8]It can be shown to hold, for example, if region i has a Cobb Douglas production technology for the numeraire.

to region 2 by way of the central authority's decision in stage 2. That is, some of the additional rent captured by the region will be redistributed (on efficiency grounds) by the authority to region 2 in the second stage of the game. This has intuitive appeal from what is well-known about inter-regional transfers needed for spatial efficiency; namely, they transfer income from high to low rent regions.

The remaining analysis focuses on the case where $\frac{\partial \rho}{\partial t_1}$ is positive so that we can see how the relationship between equalization and rent capture plays out for this case. Now reconsider the first order condition for t_1 at (4.15). Since $\frac{\partial n_1}{\partial t_1} > 0$, and $\mu_1 < 0$, it is clear that $\mu_1 \frac{\partial n_1}{\partial t_1}$ is negative. The larger labor supply induced by a higher rent tax generates a negative social marginal benefit - a negative externality - which adversely affects all existing residents of region 1 (per capita indirect utility in the region goes down). This will be perceived by region 1 as a marginal cost of an increment in the rent tax.

Similarly, if $\frac{\partial \rho}{\partial t_1} > 0$, the impact of a higher rent tax on the equalization transfer will be seen as a marginal cost of higher rent capture by the region. If the region raises its rent tax it anticipates that the central authority will increase the equalization transfer in favour of region 2. As noted, some of the higher rent accruing to region 1 is redistributed to region 2 to stop inefficient rent seeking migration into region 1.

Hence, region 1 will perceive the migration and equalization responses to its choice of rent tax to be marginal costs of an incremental increase in the tax. On the other hand, it perceives π_1 to be a marginal benefit. This is the additional rent it reclaims from foreigners - the tax exporting aspect of its rent tax which was the only variable to figure in the social planner's first order condition for the tax.

In view of this, the first order condition for t_1 can be re-expressed as an equality between marginal benefit (on the left side) and marginal cost (on the right side) as follows:

$$(t_1): \qquad \pi_1 = \frac{\partial \rho}{\partial t_1} - \mu_1 \frac{\partial n_1}{\partial t_1}. \tag{4.21}$$

Recall from the social planner problem that the first order condition for an optimal rent tax is $\pi_1 = 0$ with shadow pricing of the fixed input. This holds because the burden of the tax is fully exported to foreigners making a rent tax of 100 percent optimal. However, one can see from the above that region 1 will not set a rent tax rate of 100 percent simply because it perceives there are two locally borne costs associated with rent capture: a higher equalization transfer to region 2 and a larger labor supply which reduces per capita indirect utility in region 1.

Therefore, the *induced* equalisation and migration responses to a change in rent taxes *blunt* a region's incentive to capture local rents by providing a penalty to rent capture effort. The importance of this effect depends on the magnitude of $\frac{\partial \rho}{\partial t_1}$ and $\frac{\partial n_1}{\partial t_1}$. Measuring these responses could be a task for further empirical research.

Notice that if these effects are sufficiently large so that the marginal costs of a higher tax exceeds the marginal benefit, the tax chosen by region 1 based on (4.21) is zero. The region 1 may find it optimal not to undertake any rent capture, allowing all regional rents to flow to foreigners as private income. Another way to think of this is that it is in the interests of the region not to provide a shadow price for the fixed input, natural resources, and allow foreign-owned firms to use it for free.

One can proceed here to show that under equalization with anticipation region 1 will also provide the local public good inefficiently, with over or under provision potential outcomes. However, this finding is not new - it has already been demonstrated for games where regions provide local public goods and move first (see, for instance, pages 214-215 of Boadway et al. (2003) as well as Boadway and Tremblay (2010)). Since this is also not the focus there is no further pursuit of these results here[9].

Exactly the same findings apply to region 2 which chooses t_2 and g_2 to solve a maximization problem analogous to (4.21). This region also faces an incentive to choose a sub-optimal rent tax, including the potential of zero rent capture, because of equalization. Similarly, region 2 distorts provision of its local public good.

The rationale for this rent under-taxation result is as follows. If any region increases its effort to capture rents, and hence provide shadow prices for its fixed factors, spatial efficiency motivates the central authority to respond by redistributing income away from that region in favour of its neighbors. A regional government contemplating an increase in rent taxation anticipates this equalization response and perceives it to be a marginal cost of increasing its rent tax. This reduces its incentives to tax rents and may mean that a region finds it optimal to levy zero rent tax rates leaving all rents as private income. As a result of this induced under-taxation, an inter-regional transfer which corrects for fiscal and rent externalities in order to establish spatial efficiency can no longer establish a first best outcome.

5 Interpretation and extensions

The analysis and results depend upon a stylized model with simplifying assumptions. Apart from the standard ones, two require further comment. It was supposed all rents accrue initially to foreigners so the optimal rent tax rate is 100 percent. Under-taxation of rents in the policy game was assessed against this benchmark efficiency condition. The model can be extended to allow local and foreign ownership using share parameters. As noted, this introduces the complexity of rent tax competition between regions. In this

[9]This contrasts with Caplan et al. (2000) who find that when regions are first moves and anticipate the transfer they make efficient voluntary contributions to a national public good.

world, optimal rent tax rates are less than 100 percent since there is now a marginal cost to taxing rents: a loss of income to residents who enter the planner's welfare function. That said, the optimal tax rate is still non-zero and positive.

The first order conditions for rent taxes in the policy game also become more complex. However, they still include the two response terms - one for migration and the other for the transfer - which are the source of distortion to rent taxes. The sign of the transfer response to changes in rent taxes is also not affected by this extension.

The point is that any attempt by a region to socialize rents, whether they accrue locally or to foreigners, and disburse them on the basis of residency, is met with the same response by the central authority in order to achieve spatial efficiency; that is, the authority will redistribute some share of additional rents socialized by a region to its neighbors. This insight about rent capture and equalization is true regardless of whether rents initially accrue to foreigners, local residents or both.

To ensure per capita rent is decreasing in labor supply it was also assumed the rent consumed by a migrant to a region exceeds the positive rent externality they confer upon existing residents. If this does not hold, one cannot be sure that equalization causes the under-taxation of economic rents, though we do know that rent taxes will still be distorted by equalization, including the possibility of under-taxation. That said, there is nothing in the mathematics or economics of the model to invalidate this assumption.

Apart from these simplifying assumptions, the result was also obtained for a set of circumstances in relation to the assignment and timing of decisions. These circumstances allowed regions to anticipate central policies and distort rent taxes in order to influence their transfer. There are other combinations of assignment and timing which do not result in equalisation causing under-taxation of rents. One alternative is as follows. Let us suppose the transfer, rent taxes and local public good provision are all assigned to the regions (full decentralisation) and that decision-makers are Nash competitors. It turns out this is equivalent to the model of Mansoorian and Myers (1993), extended to give each region a rent tax. One can show that any Nash equilibrium is socially optimal with efficient transfers and rent capture.[10]

However, as noted in the paper the assignment of decision variables and timing of moves adopted in this paper are well-studied in the literature and accord with what is observed in the practice of equalisation. In this sense, the case identified in this paper that results in an efficiency problem for equalisation is quite general and the scope of application for the results reasonably broad.

[10]This model structure and solution are available from the author as a special request.

6 Conclusion

What we have learned by allowing rent capture to be modeled as an optimizing decision at the regional level is that under a plausible set of assignment and timing assumptions the transfer which corrects for fiscal and rent externalities is no longer unambiguously welfare enhancing due to the induced under-taxation of rents. In this world, in order to know whether transfers that correct for migration externalities are welfare enhancing, one needs to consider how the costs of rent under-taxation offset the gain from achieving spatial efficiency in welfare terms. Once the potential for under-taxation of rents is recognized, one should be interested in the net welfare effect of transfers designed to establish spatial efficiency. This is beyond the scope of this paper, and is left as a problem to be solved by researchers in the future. The aim in this paper has been to point out that these induced efficiency costs may exist.

The results in no way invalidate the standard efficiency-in-migration case for inter-regional transfers. The central authority must still commit to the equalization of fiscal externalities and economic rents to achieve spatial efficiency based on the well-known expression. What changes is that now spatial efficiency is achieved at the cost of sub-optimal local rent capture so it creates an efficiency cost. Also, when the center implements its inter-regional transfer, the quantum of redistribution needed may depend only upon fiscal externalities. If local services are highly congested, the amount of income redistributed across regions to establish spatial efficiency may be small.

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