

**UC Santa Barbara**  
**Departmental Working Papers**

**Title**

no title provided

**Permalink**

<https://escholarship.org/uc/item/5cb1x2jm>

**Author**

Hoel, Michael

**Publication Date**

2002-12-02

February 13, 2002

## **Interregional interactions and population mobility\***

By

Michael Hoel

Department of Economics, University of Oslo, P.O. box 1095 Blindern, N-0317.

Email: mihoel@econ.uio.no

### **Abstract**

The institutional level at which policies should be determined is an important issue that has been extensively treated in the economics literature. In particular, the literature has discussed to what extent decentralization of policy decisions give an inefficient outcome. With a homogeneous population and perfect population mobility, as it conventionally is modeled, the following result is derived for a very general class of economies with interregional interactions: A socially efficient outcome is a Nash equilibrium of the game of decentralized and uncoordinated policy setting. However, if decisions about migration take a longer time to make than decisions of policy changes, the general result above no longer holds. With this decision sequence decentralization may give an inefficient outcome also in situations where the decentralized outcome is efficient in the absence of population mobility.

*Key words:*

Interregional interaction, fiscal federalism, population mobility

*JEL classification numbers:*

D70, F02, F22, H70, H73

\* I would like to thank the Department of Economics, University of California, Santa Barbara, who gave me excellent working conditions during my visit there in the fall of 2001. A significant part of the work with the present paper was done during this visit.

## 1. Introduction

At what institutional level should policy instruments be determined? This is an important policy issue, which has been extensively treated in the economics literature during the last three decades (at least). Large countries such as USA, Canada and Australia have states or provinces below the federal level, and an important issue is what should be decided by the central (i.e. federal) government, and what should be decided by the state or province governments. The issue is also important for small countries: What should be decided by the central government, and what should be decided by local governments, i.e. counties and municipalities? Finally, in e.g. the EU there is an ongoing discussion about what policies should be common for all member countries, and what types of policies one can leave for individual countries to decide upon.

The literature on these issues has to a large extent focused on possible inefficiencies caused by decentralization of policy decisions.<sup>1</sup> The starting point of the analyses has been an economy consisting of several regions, where the regions could be states, provinces or counties within a country, or they could be individual countries within a broader union such as e.g. the EU. All of the literature assumes a considerable degree of mobility of some or all of the entities households, capital and firms. The focus of the literature has been whether the design of the tax system and/or the level of expenditure on public goods will be efficient if decisions are made at a decentralized level.

One source of inefficiency that has received considerable attention is interregional tax competition for mobile factors.<sup>2</sup> The reason one may get an inefficient outcome is that regions are competing to attract a mobile factor such as capital. The “competition” may take the form of the individual regions setting lower taxes on this factor than what would have been chosen at the central level, where one takes into account that the total amount

---

<sup>1</sup> Early contributions to this literature include Musgrave (1971), Oates (1972), Buchanan and Goetz (1972), Starrett (1980) Boadway (1982), McLure (1986) and Wildasin (1986). For excellent recent surveys, see Oates (1999) and Wellisch (2000, ch. 1).

<sup>2</sup> See e.g. Oates (1972, ch. 4), Wildasin (1986, sec. 6.3), Wilson (1986) and Zodrow and Mieszkowski (1986).

of the factor is given. When decisions about tax rates and the levels of public goods are decentralized, we may therefore get an inefficient design of the overall tax system and/or an inefficiently low level of public goods.

A second concern in the literature may work in the opposite direction as the one above: With population mobility across regions, people may own land in other regions than they live. If a public good is financed partly by a land tax, this means that the residents of a region do not bear the full costs of the public good. This thus gives the local governments incentives to spend too much on public goods.<sup>3</sup>

A third important source of inefficiency has to do with public good spillovers, i.e. that there are some benefits of a public good that accrue to residents outside the region that invests in the public good. This gives a standard type of externality across regions. The inefficiency in this case is that decentralized choice of expenditures on public goods will be inefficiently low. An important special case of this type of spillover is the “public bad” of transboundary environmental pollution. Without centralized environmental policy or other types of coordination of environmental policies across regions, one gets an inefficiently high level of pollution.<sup>4</sup>

As mentioned above, there is a large literature discussing to what extent decentralization of policy decisions give an inefficient outcome. Obviously, the answer to this question depends on what assumptions one makes about how the economy functions, and on what policy instruments are discussed. Boadway (1982) was the first to point out that the assumption one makes about population mobility can be important for the issue of whether decentralization gives an inefficient outcome. In a simple model of two regions and a local public good financed by a property tax, Boadway showed, as a response to Starrett (1980), that under the assumption of perfect population mobility the decentralized Nash equilibrium was socially efficient. The result has been extended to a somewhat

---

<sup>3</sup> See e.g. McLure (1967, 1981), Hogan and Shelton (1973), Wildasin (1986, sec. 6.3).

<sup>4</sup> Transboundary environmental problems have received a large attention in the literature; early contributions include OECD (1976) and d’Arge (1975). See also Markusen (1975), Dasgupta et al. (1997), and Hoel (1999).

more general model by Krelove (1992), although also he restricts his analysis to one without public goods spillovers and without mobile factors other than labor. Krelove also shows that restricting the possibility of local governments to tax land-rents of non-residents in general *reduces* the welfare level of everyone. Wellisch (1994, 1995 and 2000, ch. 6) has presented models in which there are interregional externalities associated with public goods, and has shown that if there is perfect population mobility, the decentralized Nash equilibrium is socially efficient. Finally, a similar result has been shown in the context of an environmental externality by Silva (1997) and Hoel and Shapiro (2002a).

The present paper shows (Sections 2 and 3) that with a homogeneous population and perfect population mobility, as it conventionally is modeled, the following result is valid for a very general class of economies with interregional interactions: A socially efficient outcome can be supported as a Nash equilibrium of the game of decentralized and uncoordinated policy setting.

Sections 4 and 5 give a critical discussion of the conventional way of modeling perfect population mobility. I argue that this way of modeling population mobility implicitly assumes that decisions of policy changes take a longer time to make than migration decisions. I demonstrate that when we instead assume that decisions about migration take a longer time to make than decisions of policy changes, the general result above no longer holds.

It is natural to ask whether the decision sequence within a single period continues to be important when the decisions are repeated period after period. In order to answer this question, the model is extended to a multiperiod model in Sections 6 and 7.

## **2. A general model**

The economy consists of  $J$  regions, which could be individual countries, or states, provinces or counties within a country. Each region has a set of policy instruments affecting the utility levels of people living in the region, and generally also the residents

of other regions. Formally, let  $X = X_1 \times X_2 \times \dots \times X_J$  be the set of feasible policies with  $X_j$  being the set of policies for region  $j$ . The vector  $\mathbf{x}_j$  is an element of  $X_j$ , and describes the policy of region  $j$ . The vector  $\mathbf{x} = (\mathbf{x}_1, \dots, \mathbf{x}_J)$  thus gives a complete description of the policy choices in all regions. It is sometimes convenient to use the obvious notation that  $\mathbf{x} = (\mathbf{x}_j, \mathbf{x}_{-j})$ , where  $\mathbf{x}_{-j}$  describes the policies of all regions other than  $j$ .

All persons in the economy studied are identical. People may have locational preferences, but whatever these are, they are shared by everyone. Since everyone is equal, everyone living in the same region gets the same utility level. We denote the utility level of a person living in region  $j$  by  $u_j$ . This utility level is given once the number of people in the region and all policies are given. Denoting the number of people living in region  $j$  (which will be regarded as a continuous variable) by  $n_j$ , we thus have

$$u_j = u_j(n_j, \mathbf{x}_j, \mathbf{x}_{-j}) \quad j = 1, \dots, J \quad (1)$$

The specification given by (1) is very general. It covers all cases of interactions between regions. These interactions can be direct externalities such as e.g. transboundary environmental pollution, but also interactions of the form that taxes and other policies in one region affect the conditions in other countries through terms of trade effects or through e.g. mobile capital.

Consider first the case when the population in each region is given. If policies are determined at the regional level, we assume that the outcome is given as a Nash equilibrium of the game where all regions choose their policy vectors simultaneously. Formally, a Nash equilibrium is a vector  $\mathbf{x}^*$  satisfying<sup>5</sup>

$$u_j = u_j(n_j, \mathbf{x}_j^*, \mathbf{x}_{-j}^*) \geq u_j(n_j, \mathbf{x}_j, \mathbf{x}_{-j}^*) \quad \forall \mathbf{x}_j \in X_j \quad j = 1, \dots, J \quad (2)$$

---

<sup>5</sup> Throughout the paper, we assume that the structure of the economy is such that there exists a Nash Equilibrium.

Whether or not such a Nash equilibrium is Pareto efficient depends on the detailed structure of the model. Formally, a Nash equilibrium  $\mathbf{x}^*$  is Pareto efficient if and only if there does not exist a feasible policy vector  $\mathbf{x}'$  such that

$$u_j(n_j, \mathbf{x}') > u_j(n_j, \mathbf{x}^*) \quad j = 1, \dots, J \quad (3)$$

In the subsequent analysis, we shall assume that all feasible policy vectors belong to the set  $X$  defined above. In many cases of comparisons between policy setting at different levels, this is a reasonable assumption. However, there may also be cases in which the set of feasible policies at a central level is larger than the set  $X$ . In other words, there may be policies that are possible to design at a central level, but that cannot be implemented at the decentralized level. One example could be a non-linear pollution tax on the total emissions from a polluting firm that has plants in several regions.

### 3. Perfect and instantaneous population mobility

In much of the literature referred to above, it is assumed that there is perfect population mobility across regions. This is formalized as migration eliminating any potential differences in utility levels between regions, so that in equilibrium population is distributed among regions so that

$$u_1(n_1, \mathbf{x}) = \dots = u_J(n_J, \mathbf{x}) \quad (4)$$

In other words, whatever the policy vector  $\mathbf{x}$  is, population reacts so that utility levels are equalized across regions. This gives the equilibrium population levels as functions of the policies chosen, i.e.

$$n_j = n_j(\mathbf{x}) \quad j = 1, \dots, J \quad (5)$$

A Nash equilibrium in the present case with population mobility is defined similarly to (2). Formally, a Nash equilibrium is a vector  $\mathbf{x}^*$  satisfying

$$u_j = u_j(n_j(\mathbf{x}_j^*, \mathbf{x}_{-j}^*), \mathbf{x}_j^*, \mathbf{x}_{-j}^*) \geq u_j(n_j(\mathbf{x}_j, \mathbf{x}_{-j}^*), \mathbf{x}_j, \mathbf{x}_{-j}^*) \quad \forall \mathbf{x}_j \in X_j \quad j = 1, \dots, J \quad (6)$$

Denoting the common utility level in (4) by  $u$ , inserting (5) into (4) gives

$$u = u(\mathbf{x}) \quad (7)$$

A reasonable definition of an efficient outcome is a policy vector that maximizes this common utility level  $u(\mathbf{x})$ , i.e. a vector  $\mathbf{x}^0$  that satisfies

$$u(\mathbf{x}^0) \geq u(\mathbf{x}) \quad \forall \mathbf{x} \in X \quad (8)$$

But such a vector must clearly also satisfy

$$u_j(n_j(\mathbf{x}_j^0, \mathbf{x}_{-j}^0), \mathbf{x}_j^0, \mathbf{x}_{-j}^0) \geq u_j(n_j(\mathbf{x}_j, \mathbf{x}_{-j}^0), \mathbf{x}_j, \mathbf{x}_{-j}^0) \quad \forall \mathbf{x}_j \in X_j \quad j = 1, \dots, J \quad (9)$$

This condition is equivalent to (6). In other words, the efficient policy vector  $\mathbf{x}^0$  is a Nash equilibrium of the game of uncoordinated policy setting.

#### 4. Perfect but “slow” migration

While the result above confirms results derived for several special cases in the literature, one may question how robust the result is. Clearly, if population mobility is not perfect, we cannot expect the result above to hold. The consequences of imperfect population mobility have been extensively studied in the literature of federalism. The two typical departures from the assumption of perfect population mobility and homogeneous populations is the existence of migration costs<sup>6</sup> and of locational preferences that differ among persons<sup>7</sup>. In Hoel and Shapiro (2002b) it is shown that when people differ, there are cases where decentralized policy setting gives an inefficient outcome when there is

---

<sup>6</sup> See e.g. Hercowitz and Pines (1991) and Myers and Papageorgiou (1997).

<sup>7</sup> See e.g. Mansoorian and Myers (1993), Wellisch (1994, 2000, ch. 7), Hoel and Shapiro (2000, 2002a,b).



perfect population mobility, even though decentralization may be efficient without population mobility.

In the present analysis we maintain the assumption of a homogeneous population, and that migration is costless. However, we relax the assumption that migration occurs instantaneously after any policy change. In the model of Section 3 (and in almost all of the literature referred to earlier) the assumption is that policies are first set, and then migration reacts to policy. It is not obvious that this is the best way of modeling population mobility: In static analyses, the sequence of moves is usually motivated by which variable in practice take the longest time to adjust. Typically, one assumes that variables that in the real world take the longest time to change are the variables that are set first. In the analysis of section 3 we have thus implicitly assumed that decisions of policy changes take a longer time to make than migration decisions. Although this probably is correct for some types of large and fundamental policy changes, it is not reasonable for decisions of the size of tax rates and similar simple decisions. It is therefore of interest to see what the consequences are of reversing the decision sequence. In this section we therefore consider the case where people first decide where to live, based on their guesses of what policies will be chosen in all the regions. After this decision has been made, policies are chosen. In a perfect foresight equilibrium, people's guesses about policies will be confirmed, and no one will regret their migration decision.<sup>8</sup>

The assumption that migration decisions take a longer time to make than decisions of policy changes is our model formalized by all population levels being given when policies are chosen. In the decentralized case, this means that we are back to the case described in section 2. A Nash equilibrium was in this case given by (2). To simplify the discussion, we assume that the structure of the economy is such that for any given distribution of the total population, there is a unique Nash equilibrium. Denoting the vector of population levels by  $\mathbf{n}$ , we thus have  $\mathbf{x}^* = \mathbf{x}^*(\mathbf{n})$ . In a perfect foresight equilibrium, this outcome will have been foreseen, and the populations will be given so

that utility levels are equal in all regions. The migration equilibrium condition (4) holds also in the present case, and the distribution of the population is implicitly given by

$$u_1(n_1, \mathbf{x}^*(\mathbf{n})) = \dots = u_J(n_J, \mathbf{x}^*(\mathbf{n})) \quad (10)$$

### 5. Efficient policies when migration is “slow”

Given perfect population mobility, we know that the migration equilibrium condition (4) must hold. The highest possible utility level one can achieve is  $u(\mathbf{x}^0)$ , as explained in Section 3. However, even if policy is centralized, one generally will not achieve this utility level if policies are determined after populations are given. Given the population distribution, an efficient policy maximizes some function

$$V(\mathbf{n}, \mathbf{x}) = \Phi(u_1(n_1, \mathbf{x}), \dots, u_J(n_J, \mathbf{x}), n_1, \dots, n_J) \quad (11)$$

that is increasing in all utility levels.<sup>9</sup> One can think of the function  $F$  as the objective function of a central government. Alternatively, the function  $F$  can express some kind of mechanism that regions have voluntarily agreed upon in order to achieve efficiency. In the context of transboundary environmental pollution, one could think of  $F$  as describing a mechanism that internalizes the interregional externalities, such as e.g. inter-regionally tradable emission permits. Whatever the interpretation of  $F$ , maximization of this function gives a policy vector that depends on  $\mathbf{n}$ , denoted  $\mathbf{x}'(\mathbf{n})$ . In a perfect foresight equilibrium, this policy will be foreseen, and the distribution of the population will satisfy

<sup>8</sup> A similar assumption is used by Mitsui and Sato (2001), who demonstrate that under this assumption it may be welfare enhancing if a central government can commit itself to not introduce any transfers between regions.

<sup>9</sup> Other reasonable restrictions on  $\Phi$  is that  $\Phi$  is independent of population levels if all utility levels are equal, and increases with a population move from one region to another region that has a higher utility level. An important special case of  $\Phi$  that satisfies these restrictions is  $\Phi = \sum_i n_i \phi(u_i)$ , where  $\phi$  is strictly increasing in its argument.

$$u_1(n_1, \mathbf{x}'(\mathbf{n})) = \dots = u_j(n_j, \mathbf{x}'(\mathbf{n})) \quad (12)$$

The policy vector and the corresponding population distribution defined by (12) will generally depend on the function  $F$ . Whatever the function  $F$  is, the policy vector  $\mathbf{x}'$  and the corresponding population distribution defined by (12) will generally differ from the first best (commitment) outcome  $\mathbf{x}^0$  and  $\mathbf{n}(\mathbf{x}^0)$ .

Whether or not the Nash equilibrium in (10) is efficient of course depends on the details of the model. However, if the structure is such that the Nash equilibrium is inefficient in the absence of population mobility, we will get an inefficient outcome also in the case with population mobility. Formally, the Nash equilibrium will only be efficient if there exists a function  $F$  giving  $\mathbf{x}'(\mathbf{n}) = \mathbf{x}^*(\mathbf{n})$  for the population distribution defined by (10).

We conclude this section with a simple example illustrating the points above. There are two countries. In both countries utility levels are simply equal to per capita consumption, which are given by

$$u_1 = 1 + f(a) - (a + b) \quad (13)$$

$$u_2 = \mathbf{g} + f(b) - (a + b) + \frac{y}{n_2} \quad (14)$$

where  $0 < \gamma < 1$ ,  $f(0) = 0$ ,  $f' > 0$ ,  $f'' < 0$ ,  $f'(a^*) = f'(b^*) = 1$  and  $y$  is positive and “not too large”. We may interpret the right hand side of (13) as the labor productivity in region 1. It can be increased by increasing a policy variable  $a$ , but this also has a cost which is borne by both regions. Similarly for region 2, which has a lower labor productivity than region 2, but has an additional exogenous income source (e.g. from a natural resource).

Consider first the case with given populations in the two regions. The Nash equilibrium of the game where the government of region 1 chooses  $a$  and the government of region 2

chooses  $b$  is simply  $a=a^*$  and  $b=b^*$ . This is inefficient, as maximization of a function of the type (11) gives

$$f'(a) = 1 + \frac{\Phi_{u_2}}{\Phi_{u_1}} \quad (15)$$

$$f'(b) = 1 + \frac{\Phi_{u_1}}{\Phi_{u_2}} \quad (16)$$

which imply  $0 < a < a^*$  and  $0 < b < b^*$ .

With perfect and instantaneous population mobility we know that population adjusts so that  $u_1 = u_2$ . It is clear from (13) that the maximal common utility is achieved for  $a=a^*$  and  $b=0$ . Provided  $(1-g+f(a^*))m < y < (1-g+f(a^*))n$  (where  $n$  is the total population and  $m$  is “1 person”, or more realistically the minimum population a region must have if it is populated), the equilibrium population will be positive in both regions. This equilibrium is also a Nash equilibrium of the decentralized policy game, as any deviation from it will reduce the common utility level.

Consider next the case when population mobility is slow. Decentralized policy will in this case be as it was without population mobility, i.e.  $a=a^*$  and  $b=b^*$ . This result will have been foreseen when migration decisions were made, so that  $n_2$  will have adjusted so that utility levels are equalized with  $a^*$  and  $b^*$  inserted into (13) and (14).

The socially efficient outcome is in this case determined by (15) and (16), which together with  $u_1 = u_2$  determine the variables  $a$ ,  $b$  and  $n_2$ . The exact values of  $a$ ,  $b$  and  $n_2$  will depend on the function  $F$ . However, whatever the specification of this function is, we see from (15) and (16) and the properties of the function  $f$  that the equilibrium values of  $a$  and  $b$  satisfy  $0 < a < a^*$  and  $0 < b < b^*$ . They thus differ both from the first best (or commitment) social optimum, and from the Nash equilibrium of the decentralized policy game when population adjustment is “slow”.

## 6. A multiperiod model

So far, we have seen that the decision sequence of policy setting and migration is important for the equilibrium policies, both under decentralized and centralized policy setting. It is natural to ask whether the decision sequence within a single period continues to be important when the decisions are repeated period after period. To answer this question, we extend our model to a multiperiod model. An additional motivation for considering a multiperiod model is that many types of public goods expenditures are investments that give benefits for several future periods.

The utility level in period  $t$  of a person living in region  $j$  is now assumed to be given by

$$u_j^t = u_j(n_j^t, \mathbf{x}_j^t, z_j^t) \quad (17)$$

where  $z_j^t$  is a state variable developing according to the difference equation

$$z_j^{t+1} = G(z_j^t, \mathbf{x}_j^t, \mathbf{x}_{-j}^t) \quad j=1, \dots, J \quad (18)$$

Notice that with this formulation, the utility in any period of people living in a region does not depend on the policies of other regions for the same period. This is a simplifying assumption that could be relaxed without changing our results.

It is assumed that the utility discount factor is  $\mathbf{b}$  for everyone.

Consider first the case of instantaneous population mobility. In the beginning of period  $t$ , the value of the vector of state variables  $z^t$  and the policy vector  $\mathbf{x}^t$  is given, and population migrates so that the utility level in this period is equalized across regions:

$$u_1(n_1^t, \mathbf{x}_1^t, z_1^t) = \dots = u_J(n_J^t, \mathbf{x}_J^t, z_J^t) \quad (19)$$

This migration equilibrium defines population levels as functions of the state variables  $z^t$  and the policy vector  $x^t$ :

$$n_j^t = n_j(x^t, z^t) \quad (20)$$

As before, we denote the common utility level in period by  $u^t$ . Inserting (20) into (19) thus gives

$$u = u(x^t, z^t) \quad (21)$$

At the beginning of period 0, the present value of this common utility level is thus

$$V(z^0, x^0, x^1, \dots, x^t, \dots) = \sum_{t=0}^{\infty} b^t u(x^t, z^t) \quad (22)$$

where the vector of state variables  $z$  develops according to (18). There is a particular policy sequence, denoted  $(*x^0, *x^1, \dots, *x^t, \dots)$  that maximizes  $V$  given by (22). This is the socially optimal policy sequence. For the same reason as given in Section 3, this policy sequence is also a Nash Equilibrium: Any deviation from it, and in particular a unilateral deviation, can only make the value of  $V$  go down, i.e. make everyone worse off.

Consider next the case in which migration is “slow” in the sense that in each period, population levels are decided before the policy is determined. In this case the equilibrium described above is no longer a Nash equilibrium. To see this, consider the situation for region  $j$ . Consider the policy above. Clearly, this sequence gives region  $j$  the following discounted utility:

$$V(z^0, x^0, x^1, \dots) = u(x^0, z^0) + bV(z^1, x^1, x^2, \dots) \quad (23)$$

or

$$V(\mathbf{z}^0, \mathbf{x}^0, \mathbf{x}^1, \dots) = u_j(n_j(\mathbf{x}^0, \mathbf{z}^0), \mathbf{x}_j^0, \mathbf{z}_j^0) + \mathbf{b}V(\mathbf{z}^1, \mathbf{x}^1, \mathbf{x}^2, \dots) \quad (24)$$

The policy sequence  $(\mathbf{x}^0, \mathbf{x}^1, \dots, \mathbf{x}^t, \dots)$  maximizes this expression. Any deviation from the policy in period 0 ( $\mathbf{x}^0$ ), will have both short run and long run effects. There will typically be deviations from  $\mathbf{x}_j^0$  that will increase  $u_j(n_j(\mathbf{x}, \mathbf{z}^0), \mathbf{x}_j^0, \mathbf{z}_j^0)$ , but that nevertheless will not increase  $V_j$  due to the negative long-run effects. However, the short-run benefits of a deviation from  $\mathbf{x}_j^0$  will typically be higher if the population level is fixed at  $n_j(\mathbf{x}^0, \mathbf{z}^0)$  than if population responds as a consequence of the deviation from  $\mathbf{x}_j^0$ , as it will if there is instantaneous mobility. The reason for this is that unlike the case of instantaneous mobility, the short-run benefits to region  $j$  by deviating from  $(\mathbf{x}^0, \mathbf{x}^1, \dots, \mathbf{x}^t, \dots)$  are not “diluted” by migration responses, spreading the short-run benefits out to all regions. This means that if we start with the first best optimum  $(\mathbf{x}^0, \mathbf{x}^1, \dots, \mathbf{x}^t, \dots)$ , and population levels are given by  $\mathbf{n}(\mathbf{x}^0, \mathbf{z}^0)$  in period 0, there will be deviations from this policy that improve the welfare of region  $j$  by so much in period 0 that this gain outweighs negative long-run effects. The policy sequence  $(\mathbf{x}^0, \mathbf{x}^1, \dots, \mathbf{x}^t, \dots)$  can therefore not be a Nash equilibrium to the game of decentralized policy setting when migration decisions must be made before policy decisions.

Notice that the argument that  $(\mathbf{x}^0, \mathbf{x}^1, \dots, \mathbf{x}^t, \dots)$  is not a Nash equilibrium when migration is “slow” does not hinge on the development of the stock variable of each region depending on policies of other regions. Instead, it is the difference in the population response in the short-run and the long run of a policy change. The effects of a policy change in the short run will not be “diluted” through migration, while the effects of the policy change in all future periods will be spread over all regions due to future migration responses. This suggests that even if there are no interregional interactions other than population mobility, we will typically get an inefficient outcome if policies are decentralized to the regional level.<sup>10</sup>

---

<sup>10</sup> What we have shown is that when policies are set at the level of the regions, we will not achieve the first best outcome that will be achieved if population responds instantaneously. However, it is not obvious that we can do better if policy is centralized, given that commitment is not possible. In the example in Section 7, we show that decentralization is inefficient also compared to centralized policy without commitment.

In a specific model of a stock pollutant, Haavio (2001) has made a similar point as the one above. In his model time is contiguous, and policy is continuously adjusted. Migration is modeled as a flow process, with differences in utility levels affecting the flow. At any instance of time, population levels are thus given, like in our case of “slow migration”. Haavio shows that even when the pollution problem is purely national (i.e. no direct interregional externalities), decentralized environmental policies give an inefficient outcome due to the (long-run) population mobility. He also considers the case where population mobility is instantaneous and shows that decentralized environmental policy in this case gives an efficient outcome.

The next Section is devoted to a simple example illustrating some of the points made above.

### 7. A 2-period example.

There are two regions. The per capita consumption in period  $t$  of people living in region  $j$  is  $c_j^t$ , giving them a utility level in this period of  $u(c_j^t)$ . Region 1 gets its income from exploiting a non-renewable resource (total amount denoted  $R$ , amount extracted in period  $1$  denoted  $r$ ), while the income in region 2 is given by a flow of a renewable resource (denoted  $y$ ). There is an inter-regional spillover, so that in period 2 region 2 also gets income from some of the resource stock that region 1 has not extracted in period 1 ( $=\alpha(R-r)$ ). In addition, we may have a transfers  $T^t$  (positive or negative) from region 2 to region 1. For region 1 we thus have

$$c_1^1 = \frac{r + T^1}{n_1^1} \quad (25)$$

$$c_1^2 = \frac{(1-\alpha)(R-r) + T^2}{n_1^2} \quad (26)$$

where the term  $\alpha$  tells us how much of the unextracted resource vanishes to region 2. For region 2 the consumption levels in the two periods are



$$c_2^1 = \frac{y - T^1}{n_2^1} \quad (27)$$

$$c_2^2 = \frac{y + \mathbf{a}(R - r) - T^2}{n_2^2} \quad (28)$$

In this economy the policy instruments are  $r$  and, if feasible, transfers from residents in one region to residents in another region.

Assume that the total population is 1, and consider an initial case of no population mobility, with a population equal to 0.5 in both regions. The Nash equilibrium is then simply given by region 1 choosing its extraction optimally, i.e. by maximizing

$$\max u(c_1^1) + \mathbf{b}u(c_1^2) \quad (29)$$

given (25), (26),  $T^1 = T^2 = 0$  and  $n_1^1 = n_1^2 = 0.5$ . This gives

$$u'(c_1^1) = (1 - \mathbf{a})\mathbf{b}u'(c_1^2) \quad (30)$$

Transfers will be zero in this Nash equilibrium. If transfers between regions for some reason are ruled out, this Nash equilibrium is Pareto efficient, although there are of course also other Pareto efficient outcomes (see Hoel (1999) for a further discussion). If transfers are allowed, it is straightforward to verify that the Pareto efficient outcomes must satisfy

$$u'(c_j^1) = \mathbf{b}u'(c_j^2) \quad j=1,2 \quad (31)$$

Inserting (25)-(28) into (31) gives two equations in the three policy variables  $r$ ,  $T^1$  and  $T^2$ . There is thus one degree of freedom, corresponding to the continuum of Pareto efficient outcomes, differing with regard to the income distribution between the two regions.

Consider next the case of instantaneous mobility. In this case per capita and utility levels are equalized in both periods. Per capita consumption in both periods must therefore simply be total income (since the total population size is 1). The common utility levels in period 1 and 2 are thus given by

$$u^1 = u(r + y) \tag{32}$$

$$u^2 = (R - r + y) \tag{33}$$

So that maximization of  $u^1 + \mathbf{b}u^2$  gives

$$u'(r + y) = \mathbf{b}u'(R - r + y) \tag{34}$$

This equation describes the social optimum for the case instantaneous mobility. As explained in Section 6, this social optimum is also a Nash equilibrium of the game of decentralized policy setting.

Consider next the case of “slow” migration, i.e. the case in which population levels in the beginning of period 1 are given. In the Appendix it is shown that when side payments are permitted, the social optimum is characterized by (34) also for this case. As we now shall see, however, the Nash equilibrium differs from the outcome described by (34).

When migration is “slow”, both regions have given populations in period 1, and for none of them will there be any benefit of giving transfers to residents in the other region.

<sup>11</sup> No country will wish to give transfers to the other country. It is true that the Nash equilibrium with zero transfers may be Pareto dominated by an outcome with the same extraction path but with  $T^1 T^2 < 0$ , but this brings us over to cooperative outcomes of various types.

Transfers are thus zero in the Nash equilibrium. The remaining policy variable  $r$  is determined by the government of region 1, which maximizes

$$V_1 = u\left(\frac{r}{n_1}\right) + \mathbf{b}u(R - r + y) \quad (35)$$

Notice that region 1 knows that whatever it does in period 1, its period 2 utility will be the same as for region 2, given by (33). Maximizing  $V_1$  with respect to  $r$  gives

$$\frac{1}{n_1}u'\left(\frac{r}{n_1}\right) = \mathbf{b}u'(R - r + y) \quad (36)$$

By assumption, people have made their migration decisions correctly, in the sense that first period utility levels are equalized, implying

$$\frac{r}{n_1} = \frac{y}{n_2} = r + y \quad (37)$$

Solving for  $n_1$  and inserting into (36) gives

$$u'(r + y) = \frac{r}{r + y} \mathbf{b}u'(R - r + y) \quad (38)$$

Comparing this with (34), we see that a decentralization of policy in this case gives a higher first period use of the non-renewable resource than what is socially optimal. Moreover, this inefficiency is independent of the parameter  $\alpha$ , which measured the degree of interregional externality from region 1 to 2. As argued in the previous section, it is the difference in the short-run and long-run population response to a policy change that causes the inefficiency.

### Appendix to Section 7: Pareto optimality when migration is “slow”

Since population levels in period 1 are given, the objective function corresponding to (11) is given by

$$V = \Phi(u(c_1^1) + \mathbf{b}u(c_1^2), u(c_2^1) + \mathbf{b}u(c_2^2), n_2^1, n_2^2) \quad (\text{A.1})$$

The policy instruments are  $r$ ,  $T^1$ , and  $T^2$ . No matter how these policy instruments are used, as long they are correctly foreseen the migration response will imply that

$$u(c_1^2) = u(c_2^2) = u(R - r + y) \quad (\text{A.2})$$

The second period utility levels will thus be independent of transfers in the second period, such transfers will only affect second period population levels.

Inserting (A.2) as well as (25)-(26) into (A.1) and differentiating with respect to  $r$  and  $T^1$  gives

$$\Phi_1 \left[ \frac{1}{n_1^1} u' \left( \frac{r + T^1}{n_1^1} \right) - \mathbf{b}u'(R - r + y) \right] + \Phi_2 [-\mathbf{b}u'(R - r + y)] = 0 \quad (\text{A.3})$$

$$\Phi_1 \left[ \frac{1}{n_1^1} u' \left( \frac{r + T^1}{n_1^1} \right) \right] - \Phi_2 \left[ \frac{1}{n_2^1} u' \left( \frac{y - T^1}{n_2^1} \right) \right] = 0 \quad (\text{A.4})$$

Since policies are assumed to have been correctly foreseen, the migration equilibrium implies that utility levels of the two regions are equal also in period 1, cf. (32). From (A.4) this implies that (since total population is 1)

$$\frac{\Phi_1}{n_1^1} = \frac{\Phi_2}{n_2^1} = \Phi_1 + \Phi_2 \quad (\text{A.5})$$

Inserting this into (A.3), and remembering that  $c_1^1 = r + y$  from (32), we thus get (34).

## References

- Boadway, R. W. (1982), "On the method of taxation and the provision of local public goods: Comment", *American Economic Review* 72: 846-51.
- Buchanan, J. M., and C. J. Goetz (1972), "Efficiency limits of fiscal mobility: an assessment of the Tiebout model", *Journal of Public Economics* 1: 25-43.
- d'Arge, R.C. (1975), "On the economics of transnational environmental externalities", in E. Mills (ed.): *Economic Analysis of Environmental Problems*, Columbia University Press, N.Y., pp. 397-434.
- Dasgupta, P., Mäler, K. G. and Vercelli, A. (eds.) (1997): *The Economics of Transnational Commons*, Clarendon Press, Oxford.
- Haavio, M. (2001), "Transboundary pollution and household mobility: are they equivalent?", mimeo, Department of Economics, University of Helsinki.
- Henderson, J. V. (1994), "Community choice of revenue instruments", *Regional Science and Urban Economics* 24: 159-83.
- Hercowitz, Z., and D. Pines (1991), "Migration with fiscal externalities", *Journal of Public Economics* 46: 163-80.
- Hoel, M. (1999), "Transboundary environmental problems", ch. 32 in Jeroen v.d. Bergh (ed.): *Handbook of Environmental and Resource Economics*, Edward Elgar, 1999.
- Hoel, M. and Shapiro, P (2000), "Transboundary environmental problems with a mobile population: Is there a need for central policy?", mimeo, University of Oslo.
- Hoel, M. and Shapiro, P (2002a), "Population mobility and transboundary environmental problems", *Journal of Public Economic*, forthcoming.
- Hoel, M. and Shapiro, P (2002b), "Transboundary environmental problems with mobile but heterogeneous populations", mimeo, University of Oslo.
- Hogan T.D. and Shelton, R.B. (1973), "Interstate tax exportation and states' fiscal structures", *National Tax Journal* 26, 553-564.
- Krelove, R. (1992), "Efficient tax exporting", *Canadian Journal of Economics* 25: 145-55.
- Mansoorian, A., and G. M. Myers (1993), "Attachment to home and efficient purchases of population in a fiscal externality economy", *Journal of Public Economics* 52: 117-32.

Markusen, J.R. (1975), "Cooperative Control of International Pollution and Common Property Resources", *Quarterly Journal of Economics* 89, 618-632.

McLure, C. E., Jr. (1986), "Tax competition: Is what's good for the private goose also good for the public gander?", *National Tax Journal* 39: 341-8.

McLure, C.E. Jr. (1967), "The interstate exporting of state and local taxes: estimates for 1962", *National Tax Journal* 20, 49-77.

McLure, C.E. Jr. (1981), "Market dominance and the exporting of state taxes", *National Tax Journal* 34, 483-486.

Mitsui, K. And Sato, M. (2001), "Ex ante free mobility, ex post immobility, and time consistency in a federal system", *Journal of Public Economics* 82, 445-460.

Musgrave, R. A. (1971), "Economics of fiscal federalism", *Nebraska Journal of Economics and Business* 10: 3-13.

Myers, G. M., and Y. Y. Papageorgiou (1997), "Efficient Nash equilibria in a federal economy with migration cost", *Regional Science and Urban Economics* 27: 345-71.

Myers, G.M. and Y.Y. Papageorgiou (1997), "Efficient Nash Equilibria in a Federal Economy with Migration Costs", *Regional Science and Urban Economics* 27, 345-371.

Oates, W. E. (1972), *Fiscal Federalism*. New York: Harcourt Brace Jovanovich.

Oates, W.E. (1999), "An essay on fiscal federalism", *Journal of Economic Literature* 37, 1120-1149.

OECD (1976), *Economics of Transfrontier Pollution*, Paris.

Silva, ECD (1997), "Decentralized and efficient control of transboundary pollution in federal systems", *Journal of Environmental Economics and Management* 32, 95-108.

Wellisch, D. (1994), "Interregional spillovers in the presence of perfect and imperfect household mobility", *Journal of Public Economics* 55, 167-184.

Wellisch, D. (1995), "Can household mobility solve basic environmental problems?" *International Tax and Public Finance* 2, 245-60.

Wellisch, D. (2000), *Theory of Public Finance in a Federal State*, Cambridge: Cambridge University Press.

Wildasin, D. E. (1986), *Urban Public Finance*. New York: Harwood.

Wilson, J. D. (1986), "A theory of interregional tax competition", *Journal of Urban*

*Economics* 19: 296-315.

Zodrow, G. R., and P. Mieszkowski (1986), "Pigou, Tiebout, property taxation, and the underprovision of local public goods", *Journal of Urban Economics* 19: 356-70.