Regional Science and Urban Economics 51 (2015) 7–13

Contents lists available at ScienceDirect

Regional Science and Urban Economics

journal homepage: www.elsevier.com/locate/regec

Comparison of Nash and evolutionary stable equilibrium in asymmetric tax competition☆

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ARTICLE INFO

Article history:
Received 11 August 2014
Received in revised form 17 November 2014
Accepted 26 December 2014
Available online 3 January 2015

JEL classification:
C72
H73
H87

Keywords:
Asymmetric tax competition
Nash equilibrium
Evolutionary stable strategy

ABSTRACT

We show that under suitable assumptions the evolutionary stable tax rate in asymmetric tax competition is strictly lower than all tax rates obtained in Nash equilibrium, generalizing in this way a recent result by Sano (Evolutionary and Institutional Economics Review 9 (2012), S1–S23) and Wagener (International Economic Review 54 (2013), 1251–1264) obtained in the context of symmetric tax competition. Our assumptions are satisfied in several models of capital and commodity tax competition.

1. Introduction

In the tax competition literature it is usually assumed that governments try to maximize utility of their jurisdiction in the *absolute* sense. If moreover they determine their tax rates simultaneously, this assumption leads to the well-known concept of *Nash equilibrium*. Recently, however, Sano (2012) and Wagener (2013) suggested that instead of maximizing the utility of their jurisdiction in the absolute sense, governments might try to maximize their *relative* performance compared to other jurisdictions. In symmetric tax competition this assumption leads to the following definition of an *evolutionary stable* tax rate (Sano, 2012, Definition 1; Wagener, 2013, Definition 1): Denoting by $u_i(t_1, \ldots, t_n)$ the utility of jurisdiction i if the tax rates are $t_1, \ldots, t_n$, a tax rate t^E is evolutionary stable if for any tax rate t

$$u_1\left(t, t^E, \ldots, t^E\right) \le u_2\left(t, t^E, \ldots, t^E\right).$$

(Because of symmetry it suffices to consider the first and second jurisdictions.)[1] The interpretation of this notion is as follows: Suppose that all jurisdictions except the first one choose the tax rate t^E. Then the government of the first jurisdiction will only choose t^E as well if there is no tax rate t satisfying $u_1(t, t^E, \ldots, t^E) > u_2(t, t^E, \ldots, t^E)$, because by setting such a tax rate the first jurisdiction would be better off than the other ones.

The assumption that governments try to maximize relative performance can be justified by the theory of yardstick competition (Besley and Case, 1995; Wrede, 2001). According to this theory voters observe policy outcomes in other jurisdictions and compare them to the situation at home. As a consequence, reelection probabilities of governments increase with relative performance, so that for a government that wants to be reelected it is very natural to maximize relative performance.

Moreover, as shown by Sano (2012, Section 5) and Wagener (2013, Section 2.5), the evolutionary stable tax rate does not only result from the attempt to maximize relative performance, but can also arise as the result of policy mimicking. Such mimicking behavior has been observed on the local level in the USA (Ladd, 1992), Belgium (Heyndels

☆ I would like to thank Thomas Eichner and three anonymous referees for their very useful comments.

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[1] Note that this definition is a special case of the concept of finite population evolutionary stable strategy (ESS) introduced by Schaffer (1988) which, contrary to the usual ESS introduced by Maynard Smith and Price (1973), is not a Nash equilibrium in general. For background on evolutionary game theory we refer to the book by Vega-Redondo (1996).

http://dx.doi.org/10.1016/j.regsciurbeco.2014.12.003
0166-0462/

and Vuchelen, 1998), England (Revelli, 2001), Spain (Solé Ollé, 2003; Delgado and Mayor, 2011), Switzerland (Schaltegger, 2004) and the Netherlands (Allers and Elhorst, 2005). Moreover, under the name "Open method of co-ordination" policy mimicking officially belongs to the means of government of the European Union, see e.g. Borrás and Jacobsson (2004) or Kerber and Eckhardt (2007).

One of the main results of Sano and Wagener (Sano, 2012, Proposition 3; Wagener, 2013, Result 2) obtained in the context of the symmetric Zodrow-Mieszkowski (1986) capital tax competition model is the following: Under evolutionary stable behavior both tax rate and welfare are strictly lower than under Nash behavior. Intuitively, this is due to the fact that relative performance maximization makes tax competition more aggressive.

The above considerations suggest that the concept of an evolutionary stable tax rate is of greatest practical importance. Unfortunately, however, Sano (2012) and Wagener (2013) obtained their result only under the highly unrealistic assumption of identical jurisdictions. In view of the importance of asymmetries in tax competition (Bucovetsky, 1991; Wilson, 1991), the following two questions naturally arise:

Question 1 *Does the concept of evolutionary stable tax rate make sense also for non-identical jurisdictions?*

Question 2 *If yes, can Sano and Wagener's result be extended to asymmetric tax competition, i.e. are tax rates and utilities still strictly lower under evolutionary stable than under Nash behavior?*

Concerning Question 1, one can easily see that – contrary to the concept of Nash equilibrium – the concept of evolutionary stable tax rate does not make sense in complete generality. However, it does make sense if the following condition is satisfied: Whenever two jurisdictions choose the same tax rate, their utilities coincide,

$$t_i = t_j \quad \Rightarrow \quad u_i(t_1, \ldots, t_n) = u_j(t_1, \ldots, t_n). \tag{1}$$

Namely, in this case we define:

Definition 1. *A tax rate t^E is evolutionary stable if for all $i \in \{1, \ldots, n\}$, all tax rates t_i and some (and then all, because of Eq. (1)) $j \neq i$,*

$$u_i\left(t^E, \ldots, t^E, t_i, t^E, \ldots, t^E\right) \le u_j\left(t^E, \ldots, t^E, t_i, t^E, \ldots, t^E\right) \tag{2}$$

(where on both sides of the inequality t_i appears at the i-th position).

The interpretation is the same as in the symmetric case: Suppose that all jurisdictions except the i-th one choose the tax rate t^E and that Eq. (2) does not hold. Then by choosing t^E as well, jurisdiction i would obtain the same utility as all other jurisdictions (because of Eq. (1)), while by choosing a tax rate t_i that violates Eq. (2) jurisdiction i would be better off than the other jurisdictions. Consequently, jurisdiction i will not choose t^E as well, and in this sense t^E is not evolutionary stable.

Of course Eq. (1) cannot be expected to hold in general, but in Section 3.1 we will see that it does hold in capital tax competition if jurisdictions may differ in size, but are otherwise equal, i.e. have the same production and utility function and the same capital endowment per inhabitant. Since many federations consist of jurisdictions which are of very different sizes, but rather similar in other economic respects, requiring Eq. (1) instead of full symmetry considerably enlarges the scope of the concept of evolutionary stable tax rate. Moreover, in Section 4 we will see that Eq. (1) also holds in Nielsen's (2001) model of commodity tax competition in the context of cross-border shopping.

Concerning Question 2, we will give an affirmative answer under suitable assumptions and show that these assumptions are satisfied in several models of capital and commodity tax competition.

Before stating our main results, let us note that the definition of evolutionary stable tax rate can be reformulated as follows:

Lemma 1. *A tax rate t^E is evolutionary stable if and only if for all $i \in \{1, \ldots, n\}$ and some (and then all) $j \neq i$.*

$$t^E \in \arg\max_{t_i} (ui - uj)\left(t^E, \ldots, t^E, t_i, t^E, \ldots, t^E\right). \tag{3}$$

Proof. If t^E is evolutionary stable, we have $(u_i - u_j)(t^E, \ldots, t^E, t_i, t^E, \ldots, t^E) \le 0$ for all tax rates t_i and, because of Eq. (1), $(u_i - u_j)(t^E, \ldots, t^E) = 0$. Hence t^E satisfies Eq. (3).

If however t^E is not evolutionary stable, there exists a tax rate t_i satisfying $(u_i - u_j)(t^E, \ldots, t^E, t_i, t^E, \ldots, t^E) > 0$, so that t^E does not satisfy Eq. (3). □

Lemma 1 shows that an evolutionary stable tax rate is the same as a symmetric Nash equilibrium in a game whose payoff functions are *utility differences*. Formalizing the idea of relative performance maximization in this way does not require condition (1), which, therefore, might seem to be dispensable. Some care should be taken, however:

1. If there are more than two jurisdictions, instead of maximizing $u_i - u_j$ for some (arbitrary) $j \neq i$, it seems more reasonable to maximize the difference of u_i and a weighted average of the values u_j, $j \neq i$.
2. Since utility is an ordinal, not a cardinal concept, the economic meaning of utility differences is questionable. If we subject a utility function to a strictly increasing transformation, it still represents the same preference relation. The resulting utility differences after such a transformation, however, can lead to a completely different Nash equilibrium.

In spite of these objections, when Eq. (1) (or a weaker version, see Remark 2 below) does not hold (namely when jurisdictions differ in other economic aspects than population size), studying a game whose payoff functions are utility differences (or quotients) seems to be the only approach to formalize the idea of relative utility maximization. Here, however, we assume Eq. (1) and leave the study of situations where Eq. (1) does not hold to future research. In the present paper, utility differences do not appear in definitions or theorems, so that their lack of economic significance is not problematic.

The paper is organized as follows: In Section 2 we formulate general conditions which ensure that under evolutionary stable behavior tax rates and utility levels of all jurisdictions are strictly lower than in Nash equilibrium. In Sections 3 and 4 we show that these conditions are satisfied in several models of capital and commodity tax competition. Finally, Section 5 concludes.

2. Nash equilibrium and evolutionary stable tax rate in an abstract setting

In this section we formulate general assumptions which, as we will show, imply the following results:

1. There exists a unique Nash equilibrium $(t_1^N, \ldots, t_n^N)$. Moreover, starting from any combination of tax rates, the usual tâtonnement process converges to the Nash equilibrium. See Theorem 1 below.
2. If the tâtonnement process is started at the vector $(t^E, \ldots, t^E)$, where t^E is any evolutionary stable tax rate, tax rates and utilities are strictly increasing. Consequently, under evolutionary stable behavior tax rates and utilities of all jurisdictions are strictly lower than in Nash equilibrium. See Theorem 2 and Corollary 1 below.

Our considerations are of a very general nature, not restricted to any particular model. We consider a federation consisting of $n \ge 2$ jurisdictions engaged in tax competition. Let $u_i(t_1, \ldots, t_n)$ be the utility of jurisdiction i if tax rates are $t_1, \ldots, t_n$. We assume that the set of