Tax Competition with and without Preferential Treatment of A Highly-Mobile Tax Base

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1. The Problem

With the ongoing integration of the world economy, it is increasingly possible for taxpayers to shift taxable income across countries. This possibility gives rise to the well-known problem of tax competition, whereby governments compete for internationally mobile sources of tax revenue by reducing the rates at which these sources are taxed. The result may be inefficiently low levels of tax revenue. See Wilson (1999) for a review of the tax competition literature.

A number of authors have studied methods for reducing the tax competition problem. But a common limitation of these methods is that they typically require a strong central authority, with the power to alter the incentives facing the governments engaged in tax competition. For example, Wildasin (1989) describes a corrective

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subsidy on the capital income raised by governments. This subsidy internalizes "fiscal externality" created by the taxation of mobile capital, whereby an increase in one government's tax causes capital to locate elsewhere, thereby benefiting other regions or countries. For further analysis, see DePater and Myers (1994) and Bucovetsky, Marchand and Pestieau (1998). The latter paper recognizes that the design of a system of corrective subsidies requires information that is difficult for a central government to obtain. Recognizing this information asymmetry, Bucovetsky et al. use agency theory to design an optimal nonlinear subsidy schedule. But the solution again requires a central authority with the ability to levy and finance a system of corrective subsidies.

A less intrusive form of intervention would be an agreement among countries to restrict the manner in which mobile goods and factors are taxed. A number of authors have recently begun to investigate one such restriction: the elimination of "preferential regimes," which allow different tax rates to be imposed on tax bases with different degrees of international mobility. The basic idea is that countries will compete vigorously over the location of highly-mobile bases, measured by the sensitivity of this location to international differences in tax rates. Indeed, if a base is infinitely elastic with respect to tax rates, then countries can be expected to engage in a form of "Bertrand competition," competing tax rates down to zero. In contrast, less mobile bases will be taxed more heavily. If all bases were required to be taxed at the same rate, then governments would no longer face incentives to tax the more-mobile bases at the low levels prevailing under preferential treatment. It is not clear, however, that the non-preferential regime would raise more revenue, because we should expect the uniform tax to lie below the taxes that would be levied on the less-mobile bases if preferential treatment were allowed.

To study this issue, Keen (2001) constructs a model with two identical countries competing over two tax bases with different degrees of mobility. The two countries play a Nash game in their tax rates, with the objective of maximizing tax revenue. He concludes that tax revenue is always higher in the preferential regime. But Janeba and Peters (1999) obtain the opposite result: tax revenue is lower in the preferential regime. Using their terminology, there are gains from nondiscrimination.

These studies differ in three ways. First, Janeba and Peters assume that one of the tax bases is perfectly mobile with respect to differences in tax rates, whereas the other is completely immobile. As previously noted, the two countries will compete the tax on the mobile base to zero, if a separate tax is allowed. Second, Janeba and Peters assume that the sizes of the tax bases depend on the levels of taxes where they are located. Third, they depart from Keen by analyzing asymmetric equilibria. The two countries are allowed to differ in the relative importance of their immobile bases as a source of revenue. In the absence of preferential treatment, one government chooses not to compete for the mobile base and instead maximizes revenue from the immobile base. This government prefers a relatively high tax rate because it generates a substantial amount of revenue from the immobile base. The other government is then free to attract the mobile base by choosing a lower rate.

To summarize, Keen shows that the preferential regime is better when countries engage in "head-to-head" competition for the mobile base, whereas Janeba and Peters show that the non-preferential regime wins when one government effectively chooses not to compete. This difference raises the question, Is the difference in results due mainly to the inclusion of country differences in the Janeba-Peters model, or to assumptions about how the tax rates influence the sizes and locations of the tax bases? Janeba and Smart (2003) address this question by generalizing the relation between the tax bases and the rates at which they are taxed. They then generalize Keen's results by showing that restrictions on preferential treatment are undesirable if the tax bases do not grow when all governments cut their tax rates, as assumed by Keen. But they also present several cases where restrictions on preferential treatment are desirable. In particular, if both bases are highly mobile but a coordinated reduction in all tax rates causes them to grow, then restrictions on preferential treatment will be desirable.

The analysis of "highly mobile" tax bases is incomplete, however, because the Nash equilibrium considered in all three papers may fail to exist when one base becomes perfectly mobile, that is, its location is infinitely elastic with respect to tax rate differences between the two countries. Indeed, nonexistence is a necessary outcome in the Keen model, where countries are identical. If both bases are taxed at the same rate (non-preferential treatment), then each country has an incentive to undercut any positive tax imposed by the other country. By offering a slightly lower tax, a country gets all of the tax base, while sacrificing only a small amount of revenue on the less-mobile base. This undercutting occurs until the tax rates both equal zero. But then each country has an incentive to raise its tax rate so that it obtains some revenue from the less-mobile base. Thus, there is no equilibrium in "pure strategies."

This nonexistence result also holds if the perfectly-mobile base is "almost" perfectly mobile. Although the less-than-perfect-mobility assumption eliminates the discontinuous jump in tax revenue in response to "undercutting," a country can still increase its tax revenue considerably by undercutting the other country's tax rate, provided the tax elasticity for the mobile base is sufficiently high. This undercutting may not lead to zero taxes, but it will lead to taxes so low that the each country would then have an incentive to increase its tax rate to capture revenue from the less-mobile base, although it sacrifices the mobile base. As Janeba and Smart explain, the problem is that a country's revenue is no longer a concave function of its tax rate. Each country may desire a high tax rate when the other country's rate is low, while also desiring a low tax rate when the other country's rate is high. The result is no equilibrium. Janeba and Smart's solution is to impose a concavity assumption, but doing so restricts the degree to which we may assume that one of the two bases is highly mobile, relative to the other. I take an alternative approach.

2. A Solution

There are two solutions to the problem of how to model competition among two identical countries when a pure-strategy equilibrium does not exist in the non-preferential regime. First, instead of assuming that the two countries set their tax rates simultaneously, we could instead model a sequential game, where one country moves first (see Janeba and Peters, 1996). But this approach introduces an asymmetry between the two countries by effectively giving one country a first-mover advantage. Thus, we still do not have an answer to what happens when the two countries compete "head to head."

The second approach is to model the mixed-strategy equilibrium for the simultaneous-move game. This approach produces an equilibrium even in the case of a perfectly-mobile tax base, because it eliminates the non-concavity described above. Each country's strategy now consists of a probability distribution for its chosen tax rates. Under the equilibrium strategy, the country is indifferent among all taxes that receive positive weight in the distribution. The country no longer faces an incentive to "undercut" the other country's tax rate, because there is no single tax rate for the other country. Rather, there is the equilibrium probability distribution of rates. If a country lowers its tax rate, it merely increases the probability that its rate will lie below the tax rate chosen by the other country, thereby increasing the probability that it will obtain the mobile tax base.

The current paper investigates whether the preferential or non-preferential regime raises the most revenue when one base is perfectly mobile, given that a mixed strategy is played in the non-preferential case. Because mixed strategies produce random tax revenue, the comparison involves a comparison between levels of expected revenue. In the next section, I conduct this comparison under the assumption that the other base is completely immobile, as in Janeba-Peters. The two regimes are found to raise the same expected revenue, in contrast to the results of both Keen and Janeba-Peters.

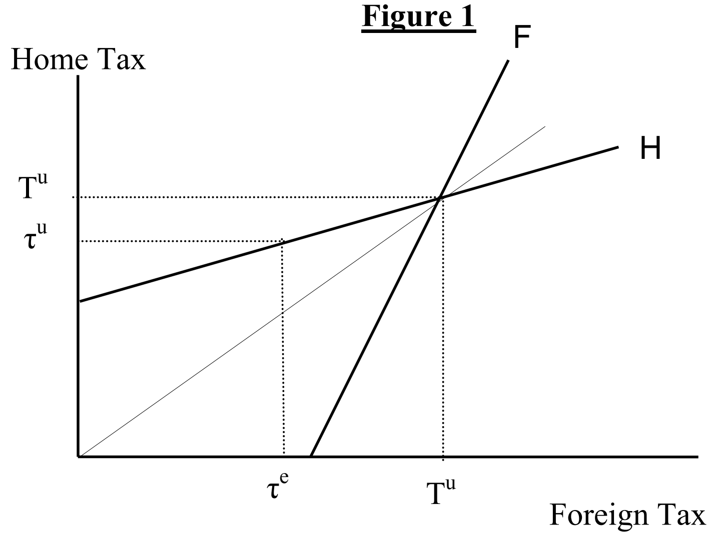
This case is relatively easy to analyze because the model is found to correspond to Varian's famous "Model of Sales" (1980). He assumes stores compete over two types of customers, informed and uninformed, corresponding to the mobile and immobile bases in the current paper. Their objective is to maximize expected profits, corresponding to expected revenue maximization. Customers purchase one or no units of a good, depending on whether the price is greater than a reservation level. With a mixed strategy, each store sells to the constant number of uninformed customers who enter the store, while selling to a fraction of the informed customers that depends on the store's price.

The similarity to the current model is evident. In the same way that a store's mixed strategy is a continuous distribution of prices in Varian's model, a continuous distribution of tax rates describes a country's mixed strategy in the current model. In place of Varian's reservation price, I assume a maximum rate at which immobile factor owners are willing to place their supplies on the market; any higher tax would reduce the factor's after-tax return below its opportunity cost. In the same way that a reduction in the store's price raises the fraction of informed customers purchasing a store's product, a reduction in a country's tax rate increases the probability that the mobile tax base locates within the country. The only real difference between the models is that Varian assumes free entry, so that store profits are competed to zero, whereas I assume a fixed number of countries (two), allowing each to benefit from their taxation of the two bases.

After analyzing this case and various generalizations that do not alter the indifference result, I replace the assumption of an immobile base with the assumption of a partially-mobile base, that is, a base that is fixed in supply for the two countries combined, but where the division of this supply between the two countries varies continuously with the difference in the countries' tax rates. I model this mobile base as a factor that is used to produce an output by means of a quadratic technology. My main results agree with Keen: the preferential regime raises more revenue.

Some rough intuition for this result may be provided using reaction curves. Consider first the preferential regime. Under the simplifying assumption that the tax imposed on one base has no impact on the other base (an assumption maintained in all of the papers discussed above), two separate tax games are played: one for the perfectly-mobile base and the other for the partially-mobile base. As previously noted, tax rates get bid down to zero in the first case. For the latter case, the equilibrium occurs where the reaction curves for the "home country" (H) and "foreign country" (F) cross. This equilibrium rate is denoted by T^u in Figure 1. Note that the reaction curves slope up. In words, a rise in foreign's tax induces more of the partially-mobile base to locate in home, and home responds by raising its tax rate.

Figure 1



Moving to the non-preferential regime, the mixed-strategy symmetric equilibrium satisfies a critical property that facilitates comparisons between the regimes: the only way for home to maximize revenue from the immobile base is to increase its tax rate to a level at which it forsakes any chance of attracting the mobile base. (Foreign's behavior is the same in this symmetric equilibrium.) Let τ^u denote this revenue-maximizing rate. In equilibrium, home can obtain the mobile base with a small positive probability by lowering its tax rate slightly below τ^u, but then it loses revenue from the immobile base. These revenue gains and losses offset each other, so that home is indifferent about reducing its tax rate; otherwise lower tax rates would not receive positive weight in the equilibrium mixed strategy.

Under the assumption of a quadratic production function, home cares only about the expected value of foreign's tax rates, denoted τ^e, not on the other properties of the distribution of tax rates. In other words, τ^u would be home's best response to a nonrandom tax rate imposed by foreign at the rate τ^e. Thus, τ^u lies on lies on the reaction curve describing home's best response to foreign's tax rate in the Nash game in pure strategies that the two countries play in the preferential regime. But τ^u exceeds τ^e, since τ^u lies at the high end of the support for the equilibrium distribution of tax rates for the Nash game in mixed-strategies. As shown in Figure 1, this excess of τ^u above τ^e means that these two rates must be below T^u, where the two reaction curves cross. In other words, moving from the preferential regime to the non-preferential regime lowers the expected tax rate facing home (along with randomizing the actual rate), thereby reducing the expected value of its share of the partially-mobile tax base. As a result, home's revenue-maximizing tax rate declines, represented by a move down home's upward-sloping reaction curve in Figure 1 from T^u to τ^u. With τ^u lying below T^u but above τ^e, home is taxing a smaller base more lightly, in comparison to the equilibrium in the preferential regime. Consequently, the expected revenue it obtains by levying τ^u lies below its equilibrium revenue in the preferential regime. Lowering its tax rate to any level τ that receives positive weight under the equilibrium mixed strategy would not change home's expected revenue (given that foreign plays the same equilibrium mixed strategy). Thus, we may conclude that the mixed strategy generates less revenue in an expected value sense than the revenue obtained in the preferential regime. In this sense, the preferential regime is superior to the non-preferential regime, a result that supports Keen.

In the next section, I discuss in detail the model of with perfectly-mobile and immobile tax bases. Section 4 replaces the immobile base with a partially mobile base, thereby obtaining the result just described. Section 5 provides some concluding remarks, including a discussion of how to interpret the mixed strategies considered here.

3. The Model with Mobile and Immobile Tax Bases

Consider two identical countries, home and foreign, that tax two bases. The two countries compete over a perfectly-mobile tax base, which is fixed in total supply. In particular, this base locates where the unit tax rate is highest. Letting t and t^* denote home and foreign's unit tax rates, the supply of the base to home is given by the function, $b(t - t^*)$, where

$$b(t - t^*) = 0 \quad \text{if } t > t^*;$$
$$b(t - t^*) = .5 \quad \text{if } t = t^*;$$
$$b(t - t^*) = 1 \quad \text{if } t < t^*. \tag{1}$$

Thus, the total size of the base is normalized to equal one, and it is split equally between the two countries if they choose the same tax rates. In a similar way, $b(t^* - t)$ describes the supply of the base to foreign. Since foreign and home are treated identically, I may describe the model by focusing on home.

The other tax base is assumed for now to be immobile internationally. Let T and T^* denote the home and foreign tax rates on the immobile base. I assume that this base is inelastically supplied at a level denoted B, if it is taxed at a rate les than or equal to some positive value, T^u. The interpretation here is that there is a fixed opportunity cost to supplying the immobile base, such as the value of its use in non-taxed activities (e.g., developed land versus undeveloped land).

Each country seeks to maximize tax revenue. In the preferential regime, home chooses t and T to maximize $tb(t-t^*) + TB$, subject to $T \leq T^u$, and similarly for foreign. In the non-preferential (or "non-discriminatory") regime, $t = T$ for home and $t^* = T^*$ for foreign. I let τ and τ^* denote these common rates.

The two countries play a Nash game in their available tax instruments. As already noted, the governments engage in a form of Bertrand competition if preferential treatment is allowed, competing t and t^* down to zero. They then raise their tax rates on the immobile base to $T = T^* = T^u$, where the return on the immobile base equals its opportunity cost. As a result, each country's total tax revenue is T^uB in the Nash equilibrium for the preferential regime.

Turning to the non-preferential regime, we have seen that there is no Nash equilibrium in pure strategies. Thus, consider a symmetric Nash equilibrium in mixed strategies. Each country's strategy is now described by a distribution function, $F()$, where the argument is τ for home and τ^* for foreign. In particular, $F(\tau)$ gives the probability that home sets its tax rates at τ or lower. Because the tax rates are random, each country faces a random tax base and, therefore, random tax revenue even if it imposes a single tax rate with certainty. If home chooses tax rate τ, its expected revenue is

$$ER(\tau) = \tau[1 - F(\tau)] + \tau B, \tag{2}$$

assuming $\tau \leq T^u$. In particular, the probability that that home's τ is lower than foreign's chosen tax rate is $1 - F(\tau)$. Since the total value of the mobile base has been normalized to equal one, home's expected revenue from the mobile base is $\tau[1 - F(\tau)]$

The support for this distribution F has $\tau = T^u$ as the top tax rate. No country would set a higher rate, because it would lose all revenue from the immobile tax base. The top tax rate also cannot be less than T^u, because then a country levying this top rate (and therefore having no chance of attracting the mobile base) could increase revenue further by raising its tax rate to T^u.

Noting the correspondence between this model and Varian's model of sales, we know that F will continuously increase from zero to one over an interval of taxes $[\tau^l, T^u]$. In other words, the density, $f(\tau) = F'(\tau)$, is positive at each τ in this interval. Each of these taxes must yield the same expected revenue; otherwise, the country could do better by shifting density from low-revenue τ's to high-revenue τ's. Thus,

$$\tau[1 - F(\tau)] + \tau B = T^uB \tag{3}$$

for each τ in $[\tau^l, T^u]$. We may conclude each country's expected revenue equals the revenue it would receive in the preferential regime, where $t = t^* = 0$:

Proposition 1. *With perfectly-mobile and immobile tax bases, the revenue raised in the preferential regime is identical to the expected revenue raised in the non-preferential regime.*

This result supports neither Keen nor Janeba and Peters. Recall that Keen concludes that a preferential regime raises more revenue, whereas Janeba and Peters make the opposite claim. Here the choice between them is a matter of indifference.

To derive the equilibrium $F(\tau)$, solve (3) for $F(\tau)$:

$$F(\tau) = 1 + B - \frac{T^u B}{\tau} \quad \text{for} \quad \frac{T^u B}{1+B} \le \tau \le T^u , \tag{4}$$

where the first inequality is obtained by solving for $F(\tau) = 0$.

Proposition 1 can be generalized in two directions, although doing so eliminates the ability to obtain a simple closed-form solution for the distribution function. First, the total size of the mobile base can be made to depend on the tax rate where it is eliminated. Specifically, replace b$(t - t^*)$ with the function $b(t - t^*, t^{min})$, where $t^{min} = min\ (t, t^*)$ and b declines with t^{min}. Once again, the tax base locates in the country with the higher tax rate, but now the size of the base depends on this countries tax rate. Given the incentives the countries face to undercut each other's tax rate, a pure-strategy equilibrium again fails to exist in the non-preferential regime. For the mixed-strategy equilibrium, this extra generality will not change the proof of Proposition 1. In particular, the support for the equilibrium distribution of tax rates is again given by an interval, $[\tau^l, T^u]$.

A more ambitious generalization is to assume that the immobile base is also a decreasing function of the country's tax rate: $B = B(T)$, where $B' < 0$ and $TB(T)$ is assumed to be single-peaked. In the preferential regime, each country continues to raise no revenue from the mobile base, instead choosing its taxation of the immobile base to maximize revenue. Let T^u now represent this revenue-maximizing rate. In the non-preferential regime, equilibrium mixed strategies are again described by a distribution function over the interval, $[\tau^l, T^u]$, for some $\tau^l < T^u$. In contrast to (4), however, the density function, $f(\tau) = F'(\tau)$, must converge to zero as τ goes to T^u. The reason is that a marginal drop in τ from T^u has a zero first-order impact on revenue from the immobile base (by the optimality of T^u). For expected revenue to stay fixed, as required under the equilibrium mixed strategy, expected revenue from the mobile base must also be unaffected by the tax reduction, implying that $F'(T^u) = 0$. With all taxes in $[\tau^l, T^u]$ providing each country with the same, expected revenue, $T^u B(T^u)$, given the other country's mixed strategy, we may once again conclude that expected revenue in the non-preferential regime is $T^u B(T^u)$, which is also revenue in the preferential regime (*where* $t = t^* = 0$).

These extensions correspond to the specification employed by Janeba and Peters. But whereas these authors show that non-preferential regimes are desirable in the case of asymmetric equilibria in pure strategies, the results here show that that the choice is a matter of indifference in the case of a symmetric equilibrium in mixed strategies.

4. Partially Mobile Capital

Let us now consider the case studied by Keen, where both tax bases exhibit some degree of mobility. While one base continues to be perfectly mobile, assume that the other base is partially mobile. In particular, increasing home's tax rate above foreign's tax rate reduces home's tax base, but does not eliminate it until the tax difference becomes sufficiently large. For the non-preferential regime, a Nash equilibrium in pure strategies fails to exist, necessitating the use of mixed strategies. For the preferential regime, the tax rate on the perfectly-mobile base is again given driven to zero, leaving the two countries to play a Nash game in their tax rates on the partially-mobile base. I start by examining this game.

Let us interpret the partially-mobile base as internationally-mobile capital, which is used to produce an output. Mobility ensures that its after-tax return, r, is equated across countries. Assume that the production function is quadratic. In particular, the relation between home's output and capital is described by the function, $G(B) = \alpha B - .5B^2$, and the same relation holds for foreign's capital, B^*. (The coefficient .5 is chosen only for algebraic convenience.) With $r + T$ denoting home's before-tax return in a non-preferential regime, profit maximization implies, $\alpha - B = r + T$. Thus, home and foreign's demands for capital are

$$B = \alpha - (r + T) \qquad \text{and} \qquad B^* = \alpha - (r + T^*). \tag{5}$$

Assume that residents in each country are endowed with $\overline{B}$ units of capital, which they may invest in either country. Then $2\overline{B}$ is the total supply of capital. The market-clearing r is then determined by the condition, $2\overline{B} = 2\alpha - 2r - T - T^*$, or

$$r = \alpha - \overline{B} - (T + T^*)/2. \quad (6)$$

Consider now the behavior of home, noting that foreign behaves in a symmetrical way. Substituting the r from (6) into (5) gives

$$B = \overline{B} + .5(T^* - T). \quad (7)$$

This condition defines home's capital demand function, $B = B(T, T^*)$. Setting $r = 0$ in (6) enables us to define a maximum average tax rate, above which no capital is supplied:

$$(T + T^*)/2 = \alpha - \overline{B}. \quad (8)$$

With taxes t and t^* bid down to zero under preferential treatment, each country maximizes its revenue from the partially-mobile base. In particular, home maximizes $TB(T, T^*)$. With B given by (7), the first-order condition is, $[\overline{B} + .5(T^* - T)] - .5T = 0$, yielding

$$T = \overline{B} + .5T^*. \quad (9)$$

The positive relation between T and T^* holds because a rise in foreign's tax rate expands home's base, giving home a greater incentive to raise its own tax rate. In the symmetric equilibrium, we set $T = T^*$ in (9) and solve for the common value, again denoted T^u:

$$T^u = 2\overline{B}. \quad (10)$$

Thus, an individual country's tax revenue is

$$R = 2\overline{B}^2. \quad (11)$$

Consider now the non-preferential regime, where each country's strategy is given by the distribution function, $F(\tau)$. If home chooses a given τ, then it faces random values of the two tax bases. The expected value of home's partially-mobile tax base, B^e, is given by (7) with τ replacing T, and with the expected tax rate associated with this mixed strategy, τ^e, replacing T^*: $B = \overline{B} + .5(\tau^e - \tau)$. Expected revenue from tax rate τ may the be written

$$ER(\tau) = \tau(1 - F(\tau)) + \tau[\overline{B} + .5(\tau^e - \tau)]. \quad (12)$$

Let τ^u denote the tax rate that maximizes revenue from the partially-mobile base. Differentiating the second term in (12) gives the following first-order condition:

$$\tau^u = \overline{B} + .5\tau^e. \tag{13}$$

Following the arguments from the previous section, F(τ) increases from 0 to 1 over the interval, $[\tau', \tau^u]$, for some $\tau' < \tau^u$, with each τ in this interval yielding the same expected revenue, ER(τ). Thus, the expected revenue yielded by the equilibrium mixed strategy is $ER(\tau^u)$. The comparison between $ER(\tau^u)$ and revenue in the preferential regime [given by (11)] then follows the arguments in Section 2. In brief, we know that $\tau^u > \tau^e$, implying that home locates at a point on its reaction curve to the left of the point, (T^u, T^u), in Figure 1, where the two reaction curves cross. Thus, the expected value of home's partially mobile base falls short of the equilibrium value in the preferential regime, and this lower base is taxed at the lower rate, $\tau^u < T^u$. Hence, we obtain--

Proposition 2. *With perfectly-mobile and partially-mobile tax bases, the revenue raised in the preferential regime is greater than the expected revenue raised in the non-preferential regime.*

5. Concluding Remarks

This paper has shown that preferential treatment of a highly-mobile tax base can represent a beneficial way of thwarting the revenue-reducing tendencies of tax competition. Without preferential treatment, tax competition erodes not only the revenue from this base, but also the revenue from less-mobile bases.

To prove this result, I had to confront the problems that highly-mobile bases create for the existence of an equilibrium in pure strategies. My solution has been to consider mixed-strategy equilibria, which consist of probability distributions over tax rates. Osborne and Rubinstein (1994) provide several interpretations of such equilibria. One interpretation is that a mixed-strategy equilibrium is a stochastic steady state. Over time, countries choose different tax rates, and each country forms its beliefs about the other countries tax rates by observing the frequencies that these other rates were chosen in the past. A problem with this interpretation is that we should expect chosen tax rates to be correlated over time, in which individual plays of the game are strategically linked.

Another interpretation is that one country's chosen tax rate is based on random private information. It would be useful to pursue this interpretation in a model with alternatives to the objective of revenue maximization. In particular, we might posit potential government decision-makers who differ in the weights they place on government revenue and some measure of resident welfare. Once again, a highly-mobile base can be expected to eliminate the existence of pure strategies in the non-preferential regime, since governments continue to have an incentive to undercut each other in an effort to attract the mobile tax base. But now the realized levels of taxation chosen in the mixed-strategy equilibrium could depend on unobservable preferences of government decision-makers over the relative weights given to revenue and welfare in their objective functions. This extension deserves further study.

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