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Abstract

This paper demonstrates, within a simple two-country model of commodity taxation and cross-border shopping, that the tax revenue (welfare) effects of a minimum tax requirement depend crucially on the character of the initial noncooperative tax equilibrium, i.e. whether it is Nash or Stackelberg.

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1 Introduction

This paper examines minimum-tax coordination proposals in a commodity tax competition framework with cross-border shopping. From an initial noncooperative tax equilibrium, two countries which differ in size (in geographical extent) implement a minimum tax requirement, and we study whether this initiative can be Pareto-improving in the sense of raising tax revenues in both countries. We assume that the initial equilibrium is either Nash or Stackelberg (with the large country as the leader). The main result of the paper is that minimum-tax coordination from a Nash equilibrium will benefit both countries, whereas the minimum-tax requirement from a Stackelberg equilibrium will only be beneficial for the large country. The small country will instead suffer a loss of tax revenue.

As it is entirely possible that authorities maximize welfare and not just tax revenue, we investigate in the last part of the paper the robustness of our results to such a change in government objectives. We there show that there are circumstances in which a minimum tax will hurt the small country, even when they play Nash. This will occur, if the minimum tax is rather high, and if the two countries have very dissimilar size.

The background for the paper is the many examples of cross-border shopping and ensuing commodity tax competition around the world. In particular, the paper is motivated by the introduction, in the early 1990s, of a floor on the standard value-added tax rate within the EU of 15 percent (and a reduced VAT rate of at least 5 percent). Commodity taxation has been intensely debated in Europe for many decades. Part of this discussion has concerned the appropriate principle for commodity taxation – destination or origin – while another part has centered on possible coordination of the rates of tax applied in EU Member Countries. In connection with the introduction of the Single Market the European Commission originally envisaged enforcing bands on VAT (and excise) rates, but the final outcome of the process was the minimum tax rates just described (for a review of the development see Keen (1993)). The message of our paper is that whether such minimum-tax coordination is in the interest of all countries involved crucially depends on the character of the initial noncooperative tax equilibrium.[1]

By now there is a considerable literature on commodity taxation and tax competition in open economies, some of the main contributions being Mintz and Tulkens (1986),

[1]The qualitative differences between Nash and Stackelberg equilibria are well known, as is the fact that intervention (here in the form of a minimum-tax requirement) may impact players differently in Nash vs. Stackelberg games. We find it important to bring this point to bear on a major economic policy issue in Europe.

deCrombrugghe and Tulkens (1990), and Kanbur and Keen (1993). Taken together, these articles demonstrate that Nash commodity tax equilibria generally imply too low tax rates (and undersupply of public goods). Further, these Nash equilibria may not always exist. Kanbur and Keen (1993) as well as Haufler (1996) investigate a minimum tax requirement plus other possible coordination initiatives within their models, but only from an initial Nash equilibrium. We extend the literature by investigating a minimum tax requirement also in a Stackelberg equilibrium and by considering welfare maximization in addition to maximization of revenue.[2]

While allowing for as well Nash as Stackelberg noncooperative commodity tax equilibria, we shall in the first part of our analysis assume, in line with much of the literature, that authorities in the two countries maximize tax revenue. However, in the latter part of the paper we deal with the case of welfare maximization. In section 2 we set up the model, and section 3 contains the analysis of a minimum tax requirement under revenue maximization. Section 4 turns to welfare maximization instead, while section 5 concludes the paper.

2 The model

Our model has two countries, together represented by the interval $[-1, 1]$. Population is evenly spread out with a density of unity in both countries. The larger of the two extends from -1 to some border parameter $b > 0$, while the smaller one extends from b to 1. Hence, population sizes are $1 + b$ and $1 - b$, respectively. This way of modelling the location of population implies variation in the distance to the border, and this has the consequence, as we shall see below, that some individuals engage in cross-border shopping, while others shop at home.[3]

There is one (composite) good in the world. Each individual purchases one unit of the good, when his reservation price exceeds the price of the good. Reservation prices in the large and the small country are denoted by V and v, respectively. We shall generally assume that these reservation prices are high enough that for the relevant tax-

[2] After writing this article our attention was drawn to the article by Wang (1998) which examines Stackelberg equilibrium in the context of the more complicated Kanbur-Keen model. Wang derives results on minimum taxes akin to those in our Proposition 2 (b) below.

[3] Our model set-up, while empirically reasonable, has the advantage of leading to a simpler commodity tax equilibrium than for instance that of Kanbur and Keen (1993). They assume that the two countries of their model have the same geographical size, but different population densities.

inclusive commodity prices resulting in the two countries, all individuals will indeed wish to purchase the commodity.

With a constant number of individuals and with the guarantee that all individuals will purchase one unit of the good, we may as well ignore the production cost of the good and set it equal to zero. Commodity taxes are specific taxes, and they are levied at the rates T in the large and t in the small country. Goods prices are then simply the relevant tax rates. For an individual to travel to the border to purchase the good abroad, a transportation cost of d per unit distance travelled[4] is incurred. While some individuals may choose this option, the rest purchase the good in the place of residence. An individual in the large country will purchase the good at the border, if the surplus obtained by doing so, $V - t - dS$, where S stands for the necessary distance travelled, exceeds the surplus from buying at home, $V - T$. Hence, those with a distance $S \leq S^* = (T - t)/d$ will opt for cross-border shopping (for $T > t$; if $T \leq t$, no-one will do so). Similarly, citizens in the small country for whom the distance to the border s fulfils $s \leq s^* = (t - T)/d$ will choose to shop abroad (again, if $t \leq T$, no-one will).

For simplicity, the objective on the part of tax authorities in the two countries is taken to be maximization of tax revenue (in section 4 we instead consider the case where authorities maximize welfare.)[5] With an open border, the two countries will have an incentive to undercut each other in order to capture tax revenue from foreigners who are led to shop across the border. This mechanism prevents tax authorities from squeezing out the full reservation prices from consumers.

Incorporating cross-border shopping, the number of residents of the large country shopping abroad is $(T - t)/d$, if $T > t$. If on the contrary $T < t$, $(t - T)/d$ small country individuals shop in the large country. Hence, tax revenues in the large and small country amount to, respectively,

$$R(T, t) = T[1 + b + \frac{t - T}{d}], \quad r(t, T) = t[1 - b + \frac{T - t}{d}] \qquad (1)$$

Noncooperative tax equilibria

[4]The cost includes the return part of the trip as well.

[5]Kanbur and Keen (1993) adopt the same assumption of revenue maximization, whereas in Haufler (1996) governments maximize preferences over private and public goods. Trandel (1994) extends the Kanbur-Keen article by demonstrating that maximizing welfare in lieu of tax revenue has no effect on which country levies the higher commodity tax.

We now imagine that the two countries, unbound by any international restrictions on their tax policies, choose their taxes in a noncooperative manner. There are two alternative noncooperative equilibria to consider in the commodity tax game: one is the Nash equilibrium, in which the two players (countries) move simultaneously; the other is the Stackelberg equilibrium, where the two players move sequentially. As to the Stackelberg equilibrium it seems most natural to focus on the case in which the large country acts as the leader.

Both noncooperative equilibria seem relevant for describing real world instances of commodity tax (or, for that matter, capital tax) competition. With countries of broadly similar size it is perhaps most reasonable to assume simultaneous moves, i.e. a Nash equilibrium. When country sizes are more dissimilar, the game might well involve the larger country setting the stage by moving first, whereas the small country then moves second. This state of affairs is then described by a Stackelberg equilibrium with the large country as the leader and the small country as the follower.

Setting derivatives of tax revenues in (1) with respect to own taxes equal to zero, we derive

$$T = \frac{d}{2}(1+b) + \frac{t}{2}, \quad t = \frac{d}{2}(1-b) + \frac{T}{2} \tag{2}$$

These are best responses of one country to tax policy in the other country (reaction functions).

Figure 1 about here

The reaction functions for the two countries (labelled L and l, respectively) are illustrated in Figure 1. The two tax rates are on the axes. It clearly emerges that at the Nash equilibrium, point N, where the reaction functions cross, the large country commodity tax is the higher one. The figure also contains the Stackelberg equilibrium (point S); it is easily seen that this solution entails higher rates of commodity tax for both countries than the Nash solution, while again the larger country has the higher tax rate. This is stated in Proposition 1 which also contains the explicit solutions for the Nash and Stackelberg commodity tax rates, the extent of cross-border shopping, and tax revenues:[6]

[6]The proof is straightforward.

PROPOSITION 1. (a) The Nash commodity tax equilibrium is well-defined and unique. It has a higher rate of tax in the large country than in the small country, the rates being

$$T^N = d(1 + \frac{b}{3}), \quad t^N = d(1 - \frac{b}{3}) \tag{3}$$

The amount of cross-border shopping under Nash is $(T^N - t^N)/d = 2b/3$, while Nash tax revenues are

$$R(T^N, t^N) = d(1 + \frac{b}{3})^2, \quad r(t^N, T^N) = d(1 - \frac{b}{3})^2 \tag{4}$$

Under Nash, the large country collects the larger tax revenue. With respect to per capita tax revenue, it is the other way around.

(b) The Stackelberg commodity tax equilibrium with the large country as the leader is likewise well-defined and unique. It also has the higher rate of tax in the large country, and the two rates are

$$T^S = d(\frac{3}{2} + \frac{b}{2}), \quad t^S = d(\frac{5}{4} - \frac{b}{4}) \tag{5}$$

The amount of cross-border shopping under Stackelberg is $(T^S - t^S)/d = (1 + 3b)/4$ and so higher than under Nash for any value of b. Stackelberg tax revenues amount to

$$R(T^S, t^S) = \frac{d}{2}(\frac{3}{2} + \frac{b}{2})^2, \quad r(t^N, T^N) = d(\frac{5}{4} - \frac{b}{4})^2 \tag{6}$$

The small country always collects the bigger per capita tax revenue in the Stackelberg equilibrium. For values of b close to zero, it also collects a bigger absolute revenue, while for greater values of b the large country collects more revenue.

Comparing the expressions for tax revenues in (6) with those in (4) it is easily seen that both countries collect more revenue in the Stackelberg equilibrium than in the Nash equilibrium. This fact also emerges from looking at the iso-revenue curves in Figure 1.

3 A minimum-rate constraint on commodity taxes

Both Nash and Stackelberg commodity tax equilibria are inefficient. For instance, small joint tax increases can clearly raise tax revenue in both countries. To see this in the case of Nash equilibrium, note first that a small increase in the tax rate in either country will have no effect on its own revenue (since the tax was set to maximize revenue). But the cross-effect is positive: An increase in the tax in one country obviously raises revenue in the other, as can be seen directly from the revenue expressions in (1). A similar argument can be made from the Stackelberg equilibrium after adding the condition that the increase in the small country's tax be bigger than the increase triggered by the raise in the large country's tax. Other acts of commodity tax coordination than such joint marginal tax increases may have the same effect.

One form of commodity tax coordination which has been widely debated and actually implemented in the EU is that of a mandated minimum tax. To investigate the effects of a minimum tax requirement (henceforth, MTR) we conduct the following experiment: We imagine the existence of some supranational authority – such as the Council of European Union – that, worried by the outcome of unfettered commodity tax competition, decides on a certain minimum level for commodity tax rates. Further, we take it that the character of international cooperation is such that countries feel compelled to accept the MTR and commit to obeying it. We do not envisage the MTR to be optimally set in any way, only that the required minimum rate lies between the noncooperative rates of tax in the two countries.

To be more precise, both countries are from now on required to levy the commodity tax at least at a rate τ, where τ lies between the two Nash (respectively Stackelberg) tax rates t^N and T^N (t^S and T^S). Faced with this MTR, the countries select their actual values of commodity tax rates in the same way as before the MTR: If they played Nash (Stackelberg) before, they also do so afterwards. Hence, in essence the commodity tax game is the same as before, except that the choice of feasible tax rates is limited by the MTR. In particular, the reaction functions of the two countries will be changed into

$$T_m = \max(\tau, \frac{1}{2}[d(1+b)+t_m]), \quad t_m = \max(\tau, \frac{1}{2}[d(1-b)+T_m]) \tag{7}$$

where the subscript 'm' refers to tax setting under the MTR. In line with these reaction functions, if the large country selects a low rate of tax, the small country may have to select the minimum tax rate. If on the other hand the large country chooses a high rate, the small country can select the value $[d(1-b)+T_m]/2$ as before. Similarly for the large country's reaction, if the two countries play Nash. For the Stackelberg game, the large country will select its tax to maximize its tax revenue, subject to $T_m \geq \tau$ and to the small country's reaction function in (7).

The minimum tax requirement issued by the supranational authority can be interpreted as a cooperative device in the sense that the two countries are forced to alter their commodity tax strategies in a direction which perhaps ex ante looks promising. In reality, though, the commodity tax game is still noncooperative, albeit now subject to the MTR. In particular, it is not a fully cooperative game.[7] Moreover, as stressed above, no particular optimization attempt lies behind the selection of the minimum tax rate.

For the minimum tax experiment we can show the following:[8]

PROPOSITION 2. (a) A minimum tax requirement $t_m, T_m \geq \tau$, where $\tau \in (t^N, T^N)$, will benefit both countries, if the noncooperative commodity tax equilibrium is Nash.

(b) If instead the noncooperative tax equilibrium is Stackelberg, a minimum tax mandate $t_m, T_m \geq \tau$, where $\tau \in (t^S, T^S)$, can never benefit the small country, but it will be beneficial for the large country.

Proof: (a) It is easy to see that the minimum-rate constraint will bind for the small, but not the large, country in the new Nash equilibrium. Assuming, for instance, that the small country tax exceeds τ will quickly lead to a contradiction, when reaction functions in (7) are applied. Figure 2 demonstrates that the small country will indeed choose the minimal tax rate. Panel (a) in the figure illustrates the MTR in the case where the initial noncooperative equilibrium is Nash. The new reaction curves are kinked, due to the MTR. The MTR is easily seen to entail a move from the previous Nash equilibrium N up the large country's reaction curve to the new equilibrium N'; the small country chooses the minimum rate τ, while the large country responds by setting a somewhat higher tax, as given in (7). Given this, and using (1) and (7), the tax base of the small country can be written $(3/2) - (b/2) - (\tau/2d)$, whence its tax revenue clearly is concave in τ. For $\tau = t^N$, the minimum tax is just not binding, and the small country derives unchanged revenue. The derivative of the tax revenue with respect to τ in this point is positive. Furthermore, for $\tau = T^N$ the small country collects a higher revenue than in the initial non-cooperative equilibrium, and the same must therefore be true for all intermediate values of τ. As to the large country, since its tax revenue can be written as $d[(1 + b)/2 + \tau/(2d)]^2$, again by the use of (1) and (7), it will clearly collect a higher

[7]The reason being that we do not think a cooperative game is a good description of tax coordination attempts in reality.

[8]Kanbur and Keen (1993) show part (a) of Prop. 2 in their model in which the two countries differ in population density rather than in geographical extent. Haufler (1996) examines a mandated minimum tax from the Nash equilibrium in a model with two countries differing in preferences for public goods. He fails to reach unambiguous welfare results and stresses that there is a distinct possibility that the small country loses from tax coordination. We demonstrate in part (b) of Prop. 2 that this occurs with certainty under coordination from the Stackelberg equilibrium.

revenue than in the non-cooperative equilibrium for all $\tau > t^N$. Figure 2 (a) indeed suggests that the minimum tax requirement will be to the advantage of both countries.

(b) With the Stackelberg formulation the large country is in a position to select a point on the small country's kinked reaction curve, either on the flat part where $t_m = \tau$, or on the upward-sloping part where $t_m = [d(1-b) + T_m]/2$. At the same time, the large country itself must obey $T_m \geq \tau$. The situation is illustrated in panel (b) of figure 2. It is clearly in the interest of the large country to induce $t_m = \tau$, that is have the small country levy the minimum tax. The large country will choose $T_m = [d(1+b) + \tau]/2$, if this exceeds τ, and $T_m = \tau$ otherwise, so that, as in figure 2, adhering to the MTR implies a sideways jump away from the previous small country reaction curve without the MTR to either the large country reaction curve or the 45 degree line (cfr. point S'). Closer scrutiny will reveal that the first of these options is not available for all values of b, and in the end we can characterize the Stackelberg equilibrium with the MTR by: (i) If $b \leq 1/5$, then $T_m = t_m = \tau$; (ii) if $b > 1/5$, then for $\tau < d(1+b)$, $t_m = \tau$ and $T_m = \frac{1}{2}[d(1+b) + \tau]$, whereas for $\tau \geq d(1+b)$, $T_m = t_m = \tau$. In any case, the large country derives a revenue greater than $(1+b)t^S$, and this in turn is at least as large as the original Stackelberg revenue. As for the small country, its revenue increases in the large country's tax. Because the new Stackelberg equilibrium features a smaller tax in the large country, and the small country's tax setting is restricted, it will unambiguously collect a smaller revenue. It is readily seen from figure 2 (b) that the MTR in the Stackelberg equilibrium can never be to the advantage to the small country, while the large country stands to benefit. *End of proof.*

Figure 2 about here

4 Welfare rather than tax revenue maximization

Until now we have assumed that tax authorities in the two countries have aimed at maximizing tax revenue. This is one possible objective on the part of the government, and the analysis of tax equilibria before and after a MTR becomes particularly simple with this objective. It is, of course, entirely possible, even more likely, that in reality tax authorities aim to maximize more broadly defined welfare of society. It is therefore important to examine whether our results extend to a setting in which authorities maximize welfare rather than tax revenue. To pursue this, assume that the marginal cost of public funds

(MCPF) is constant and the same in the two countries.[9] Denote the MCPF by ρ, $\rho > 1$. Welfare expressions in the two countries, W and w respectively, can then be written[10]

$$W(T,t) = (V-T)[1+b-\frac{T-t}{d}] + \int_0^{(T-t)/d} (V-t-ds)ds + \rho R(T,t) \qquad (8a)$$

and

$$w(t,T) = (v-t)(1-b) + \rho r(t,T) \qquad (8b)$$

with $R(T,t)$ and $r(t,T)$ as given in (1). In both cases, welfare is the sum of consumers' surplus and tax revenue, the latter weighted by the MCPF. Note that maximization of tax revenue is the special case of ρ going to infinity. In a manner completely parallel to the analysis above, it is now possible to derive the reaction functions for the two countries:

$$T = \frac{d(1+b)}{2+\frac{1}{\rho-1}} + \frac{t}{2+\frac{1}{\rho-1}}, \quad t = \frac{d(1-b)}{2\frac{\rho}{\rho-1}} + \frac{T}{2} \qquad (9)$$

These reaction functions clearly show that welfare maximization intensifies the degree of tax competition in the sense of producing lower tax rates than with tax revenue maximization. The intercepts of both reaction functions fall, and in addition the slope of the large country reaction function declines.[11] Using the reaction functions we can derive the Nash and Stackelberg equilibria. In particular, the Nash equilibrium tax rates become

$$T^N = \frac{d(\rho-1)\left(3\rho-1+b(\rho+1)\right)}{\rho(3\rho-1)} \qquad (10a)$$

$$t^N = \frac{d(\rho-1)(3\rho-1-(\rho-1)b)}{\rho(3\rho-1)} \qquad (10b)$$

Clearly, for ρ going to infinity, indicating that authorities are in effect maximizing tax revenue, we recover the formulas in (3).

In Proposition 2 a main point was that under revenue maximization, imposing a minimum commodity tax rate cannot benefit the small country, if the initial situation is characterized by Stackelberg equilibrium, whereas it will be beneficial from a Nash

[9] The MCPF will reflect how distortionary the rest of the tax system is.

[10] The formulas presuppose cross-border shopping from the large to the small country. It is easy to see that both Nash and Stackelberg equilibria with welfare maximization will have this feature.

[11] The reason for the latter effect is as follows: When the large country raises its tax in response to a higher tax in the small country, it also has to take into account the loss of consumer surplus and transportation costs owing to cross-border shopping. The lower the MCPF, the more important will these costs become.

equilibrium. It is now possible to demonstrate that this latter conclusion may not always hold for the case of welfare maximization; that is, when the two countries maximize welfare rather than tax revenue, there are circumstances under which the small country will be hurt by a MTR in the Nash commodity tax game.

We start out observing that the small country will levy the commodity tax at the minimum rate (just as under revenue maximization). Moreover, an almost non-binding minimum tax rate (i.e. τ only slightly larger that the Nash rate of the small country, t^N) will be beneficial for the small country. Its welfare, as a function of the minimum-rate τ, can be written

$$w = v(1-b) + \tau(\rho-1)(1-b) + \rho\tau(\frac{T_m(\tau)-\tau}{d}) \tag{11}$$

where $T_m(\tau)$ signifies the large country's choice of tax rate as a function of the minimum-rate τ, that is (9) with τ inserted for t. Note that the expression in (11) is concave in τ. Varying τ produces welfare changes according to

$$\frac{\partial w}{\partial \tau} = \frac{1}{d(2\rho-1)}\left[d(\rho-1)(3\rho-1-b(\rho-1)) - 2\rho^2\tau\right] \tag{12}$$

Letting $\tau = t^N$we find

$$\left.\frac{\partial w}{\partial \tau}\right|_{\tau=t^N} = \frac{(\rho-1)^2(3\rho-1-b(\rho-1))}{(2\rho-1)(3\rho-1)} \tag{12'}$$

which is > 0 for $\rho > 1$. Hence, whenever public funds are scarce, as symbolized by a MCPF in excess of unity, a small forced increase in the small country's tax rate is beneficial for it.

Next we note that we have allowed the minimum tax rate to take on any value in the interval (t^N, T^N). If the largest possible value is selected, $\tau = T^N$, we need to compare small country welfare levels $w(T^N, T_m(T^N))$ and $w(t^N, T^N)$. Tedious calculations establish that

$$w(T^N, T_m(T^N)) - w(t^N, T^N) > 0, \text{ as } \rho > \frac{2-b}{3(1-b)} + \sqrt{\frac{1+2b-2b^2}{9(1-b)^2}} \tag{13}$$

The expression on the RHS of (13) approaches unity from above, as b goes to zero (from above). Hence, given that the MCPF exceeds unity, a small enough b will fulfil the inequalities in (13). So even the maximum value for the minimum rate will cause a welfare improvement in the small country, if the two countries are not too dissimilar.

Now, suppose b approaches unity. Then the expression on the RHS of (13) goes to infinity. This implies that when the two countries are sufficiently dissimilar, a minimium tax rate close to the Nash rate in the large country will deteriorate welfare in the small country.

We sum up our findings in this section in Proposition 3:

PROPOSITION 3. If the two countries are maximizing welfare rather than commodity tax revenue, then introducing a minimum tax rate in the Nash equilibrium will benefit both countries, provided they are not too dissimilar. However, if the small country is very small relative to the large country, and if at the same time the minimum tax rate lies close to the large country Nash tax, the minimum tax will be detrimental to the small country.

In other words, a modification of Proposition 2 (a) is therefore needed to cover the case of maximization of welfare rather than tax revenue. Our investigations have not, though, indicated any need to modify part (b) of Proposition 2 for the case of welfare maximization.

5 Conclusion

This paper has set up a simple model of commodity tax competition in the face of possibilities for cross-border shopping. The model has two countries, one larger than the other in geographical extent. Tax authorities are assumed to maximize revenue from commodity taxation. The size asymmetry produces a wedge between the noncooperative commodity tax rates in the two countries and therefore some cross-border shopping, regardless of whether the two countries play Nash or Stackelberg (with the large country as the leader).

In both Nash and Stackelberg tax competition equilibria, tax rates are generally too small, calling for some form of coordination. We specifically analyze the effects on tax revenues in the two countries of introducing a minimum tax requirement, concluding that a minimum tax constitutes a Pareto-improvement from the Nash, but not from the Stackelberg equilibrium, since the small country will suffer a tax revenue loss. With one exception detailed above, the same conclusion is obtained, if the two countries maximize welfare in lieu of tax revenue. Hence, in a commodity tax competition situation, it is crucial to diagnose the type of noncooperative game being played before proposing a minimum tax.

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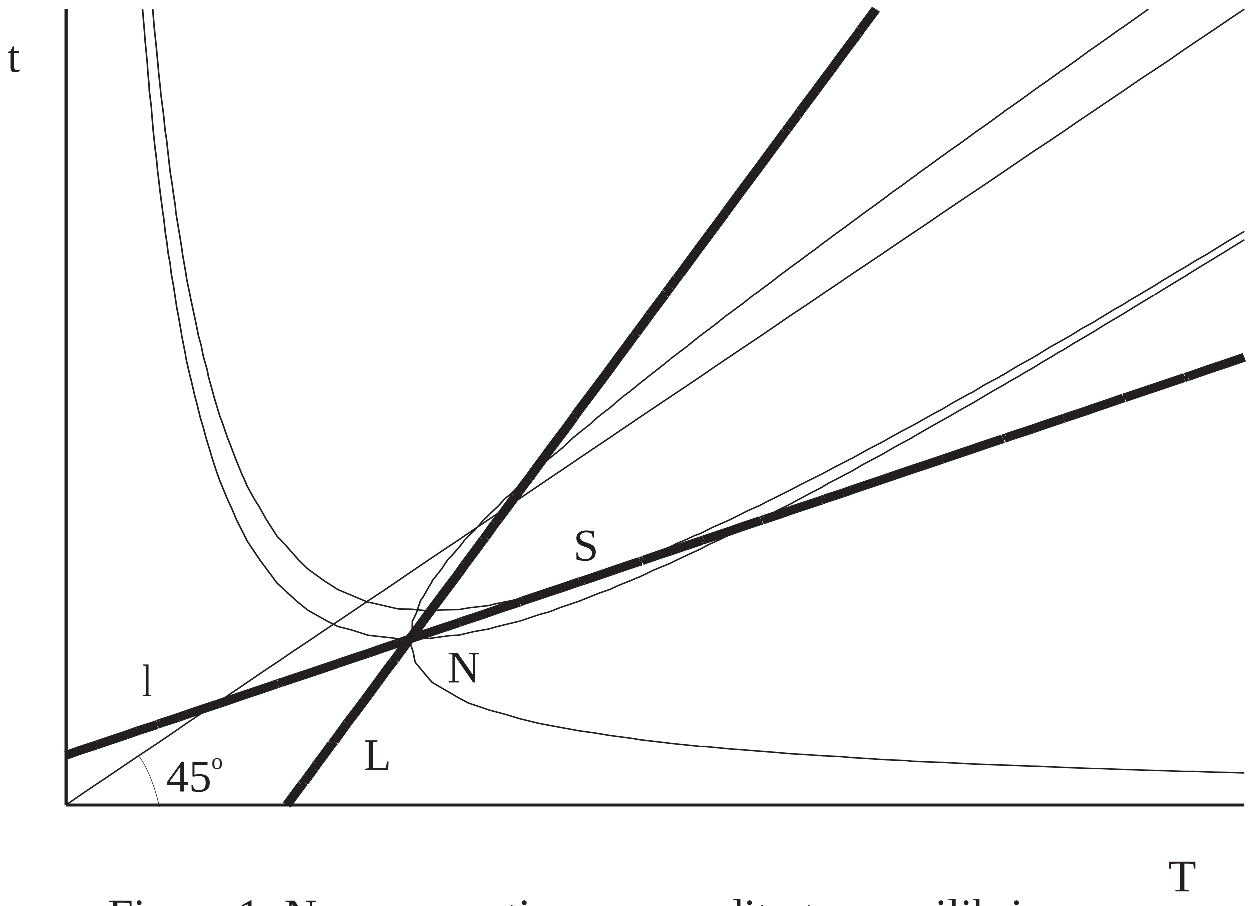

Figure 1: Noncooperative commodity tax equilibria.

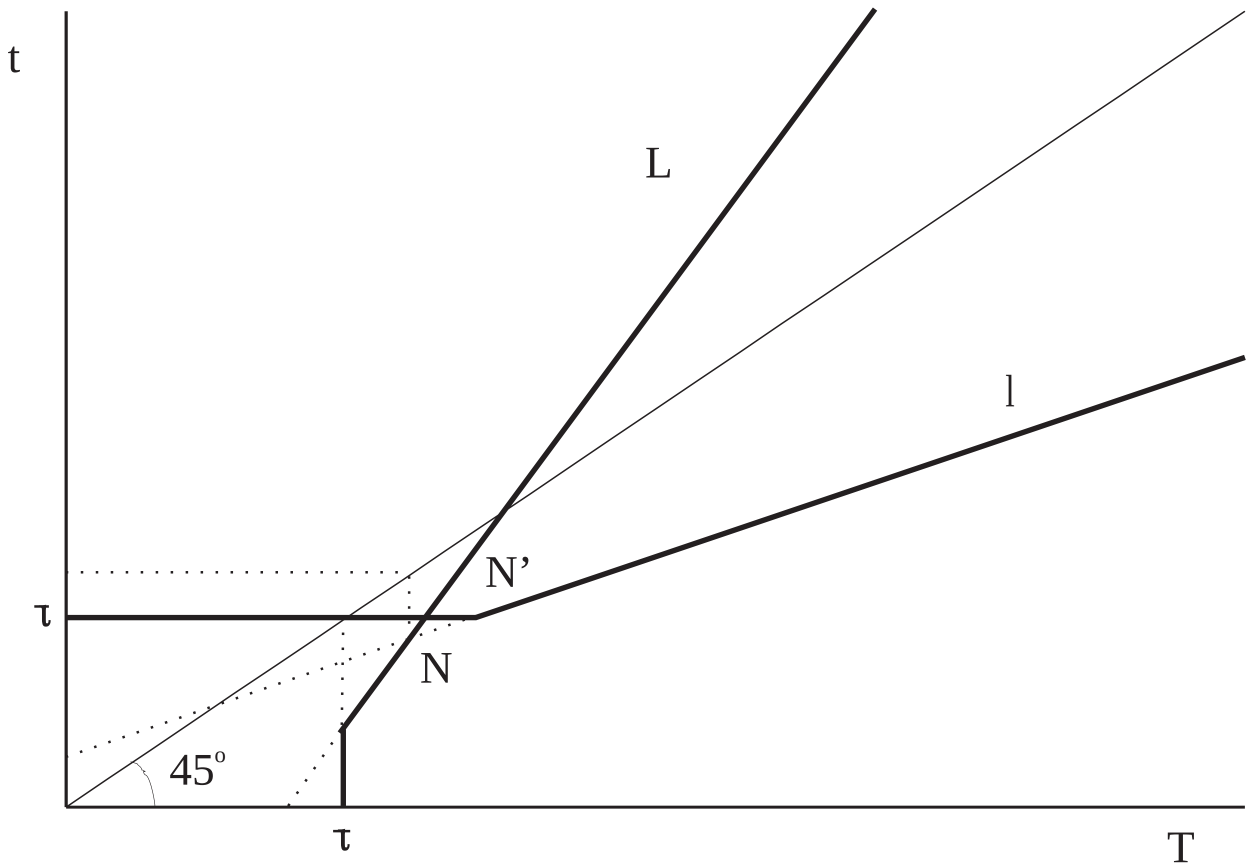

Figure 2a: Minimum-rate tax with Nash-equilibrium

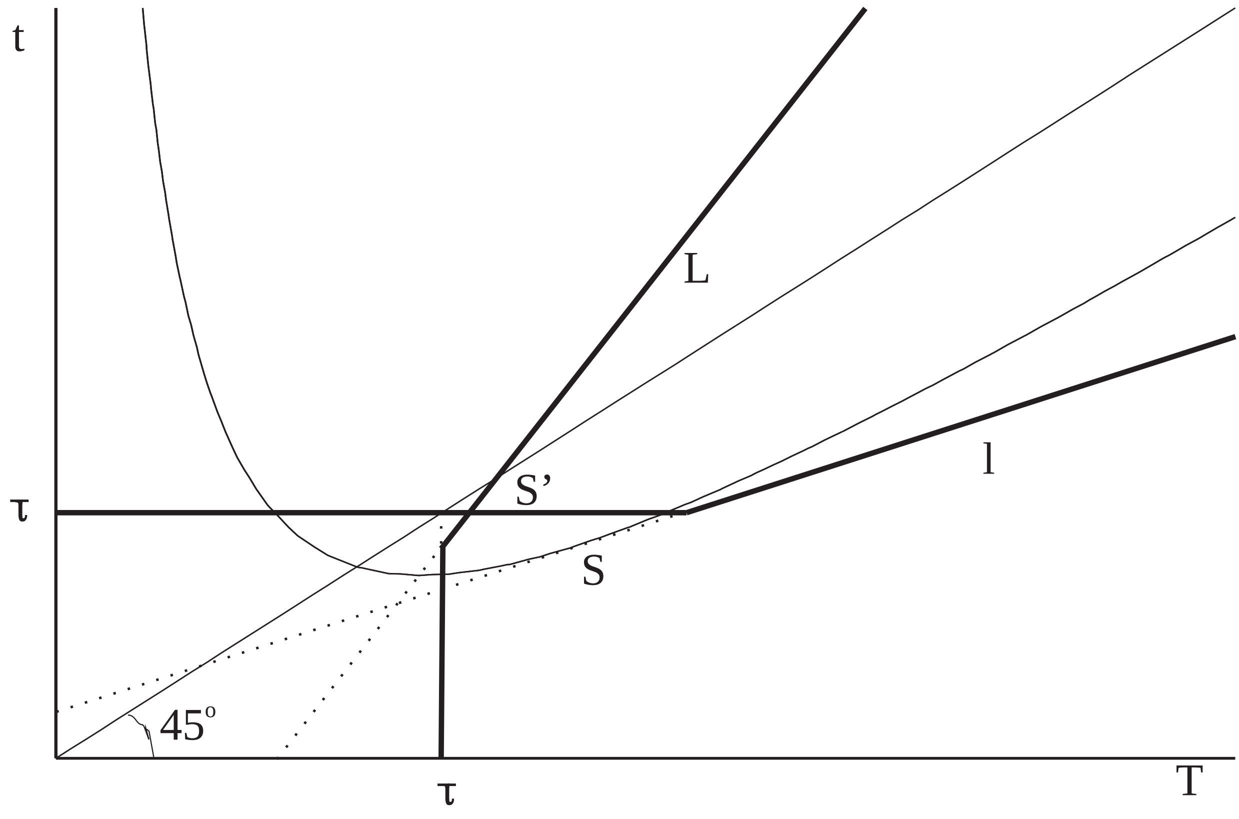

Figure 2b: Minimum-rate tax with Stackelberg equlibrium