Tax competition with evasion

Gandelman, Néstor
Hernández-Murillo, Rubén

Documento de Trabajo Nro. 7
Facultad de Administración y Ciencias Sociales
Universidad ORT Uruguay
Agosto de 2000
ISSN 1510-7477

Documento de Trabajo

UNIVERSIDAD ORT
Uruguay

ISSN 1510-7477

Tax Competition with Evasion *

Néstor Gandelman, Universidad ORT del Uruguay
Rubén Hernández-Murillo, Federal Reserve Bank of St. Luis **

Documento de Trabajo Nº 7
Facultad de Administración y Ciencias Sociales
Universidad ORT Uruguay

Agosto 2000

* We thank Elizabeth Caulcutt, Manfred Dix, Juan Dubra, Federico Echenique, Hugo Hopenhayn, Per Krusell, Gerard Llobet and Alan Stockman. All errors are, of course, our own.

** The views expressed are those of the authors and do not necessarily represent official positions of the Federal Reserve Bank of St. Louis, or the Federal Reserve System.

Tax Competition with Evasion

Néstor Gandelman
Universidad ORT and CERES

Rubén Hernández-Murillo
Federal Reserve Bank of St. Luis

August 2000

Abstract

This paper examines a multicommunity environment with competition among local governments for tax base. Local governments can verify whether agents pay taxes or not but can only imperfectly monitor where contributions are made. Individual agents enjoy the local public good, but may decide to cheat and pay taxes not in their place of residence, saving the tax difference.
The cheating decisions of individual agents is analyzed. The Nash equilibrium of the game with symmetric and non-symmetric communities is characterized. If communities are identical the equilibrium must be symmetric. When communities differ in size, smaller communities have stronger incentives to lower their tax and attract agents from neighboring communities. In equilibrium smaller communities set lower taxes.
If communities differ in income distribution there are two opposing effects. Decreasing taxes may attract neighbors, increasing the tax base (stealing effect). But if local agents do not tend to take chances, increasing taxes even at the cost of reducing the tax base may increase total revenue (captive effect). The overall effect is ambiguous.
Finally, the optimal monitoring policy of a high tax community is characterized.

Abstract

Este documento examina competencia entre gobiernos locales por base fiscal. Los Gobiernos Locales pueden verificar si los agentes residentes pagaron impuestos o no, pero no pueden verificar perfectamente si los agentes pagaron impuestos donde deberían haberlo hecho. Los residentes de una localidad de altos impuestos, pueden decidir evadir en la comunidad local y pagar impuestos en una comunidad vecina ahorrándose la diferencia.
La decisión de evadir de los agentes es analizada. El equilibrio de Nash del juego con comunidades idénticas y con diferencias en tamaño y distribución del ingreso es caracterizado. Si las comunidades son idénticas el equilibrio tiene que ser simétrico.
En caso que las comunidades difieran en tamaño, la comunidad más pequeña tiene mayores incentivos a fijar una tasa baja y atraer agentes de la comunidad vecina. En equilibrio, la comunidad menor fija impuestos más bajos.
Cuando las comunidades tienen diferente distribución del ingreso existen dos efectos opuestos. Bajar los impuestos puede atraer agentes vecinos ampliando la base impositiva (stealing effect). Pero si los agentes no son proclives a arriesgar, aumentar los impuestos aún a costo de reducir la base impositiva puede resultar en ingresos fiscales mayores (captive effect). El efecto global es ambiguo.
Finalmente se caracteriza la política de control óptima de una comunidad de impuestos altos.

1 Introduction

In this chapter we examine an environment where local authorities compete to maximize revenues from residence-based personal taxation, and individuals have the ability to evade taxes via illegal cross-border shopping, i.e., individuals can choose in which community to pay their contributions by lying about their place of residence. Local governments can verify if individual agents have paid taxes, but can only imperfectly monitor if they do it in their community of residence. Residents in each community are ordered in terms of risk aversion and face different incentives towards tax evasion, and governments in each jurisdiction take their responses into account when setting tax rates.

Examples of illegal cross-border shopping to avoid taxes in the US include smuggling of alcohol and tobacco across state borders. Although the consumption of alcohol and tobacco is not illegal, in many instances, shipping these goods across borders is. Empirical studies suggest that cross-border shopping of alcohol and tobacco is a significant factor in explaining sales differentials between US states, see for example Saba et al. (1995), Crawford and Tanner (1995) and Beard et al. (1997). This evidence suggests that cross-border shopping may hinder the ability of local and state governments to raise tax revenues. Recently, the popular press has remarked the potential impact of on-line trade on tax avoidance of state sales taxes. In the international context, cross-border shopping across countries appears to be a significant source of evasion of value-added tax. Gordon and Nielsen (1997), for example, compare tax evasion in an open economy under regimes of value-added and income taxation.

One way of analyzing this issue is by modeling competition among states that strategically account for the cross-border shopping induced by tax differences across locations. In our framework we characterize the individual decision of whether to evade taxes under the assumption of risk aversion. We also explore the problem of designing a monitoring policy for a high-tax community and examine the implications of size and income differences across communities on the relative tax rates set by rival locations. We extend existing results in the literature to the case of risk-averse agents that small communities set lower taxes in equilibrium because they generate more revenues attracting a larger mass of tax evaders from the large community than what they give up from their small tax base at home.

In the literature on tax competition, Bucovetsky (1991) and Wilson (1991) analyze the effects of jurisdiction size on the equilibrium tax rates and find analogous results in a representative agent framework. In a spatial competition framework, Kanbur and Keen (1993) and Ohsawa (1999) are particularly interested in identifying what countries choose to become tax havens. They obtain analogous results for the case of risk-neutral individuals. Neither of these approaches examines tax evasion.

Another instance of cross-border shopping in the US, is the system of car registration fees. States demand every vehicle to display a license plate in order to circulate, and since registration fees may differ across local or states governments, agents may illegally choose to register their car in a neighboring low-tax community (this may require vehicle owners to produce proof of residence in that community). It is easy to verify that a car owner has paid registration fees somewhere, but there is no easy way to check where motorists actually drive their cars, since local authorities do not know if a car with out-of-state plates has been in the state for one week or one year. There are, however, penalties for perpetrators that are caught. Given a monitoring technology, the individual decision problem can be modeled as a binary choice problem of choosing to pay taxes at home, or facing the gamble of paying taxes in the low-tax community. The intuition of treating tax evasion as a lottery was first developed by Allingham and Sandmo (1972), and has been widely used in the literature on income tax evasion.

Casual evidence suggests that this problem may be of some relevance. For example, the Minneapolis Star Tribune[1] reports that "an estimated 35,000 Minnesotans have illegally registered their cars in neighboring states, mostly in Wisconsin, which has lower annual registration fees." This represents, they say, approximately $3.5 million lost in the state's highway trust fund, to which total registration fees contribute 47% (almost $450 million). License tabs for cars in Minnesota range from $35 to about $475, while Wisconsin has a flat fee of $45. In case of prosecution, sentences can be up to one year in jail and a $3,000 fine. The Boston Globe[2] relates the case of Massachusetts and New Hampshire: insurance costs in Massachusetts are much higher than in New Hampshire, where auto insurance is not even required until the first accident occurs. The Globe also relates the concern of the Insurance Fraud Bureau, which estimates the costs in lost insurance, taxes, and fees to the state at about $1,200 a year per unregistered car.

Comparing the pattern of registered cars in the US with the number of cars people report to own in the 1990 Census, some states appear to show an influx of cars from other states. Massachusetts, in particular, seems to be surrounded by receptor states. The map in Figure 1 shows the number of registered cars by state compared against the number of cars owned by households in 1990.[3]

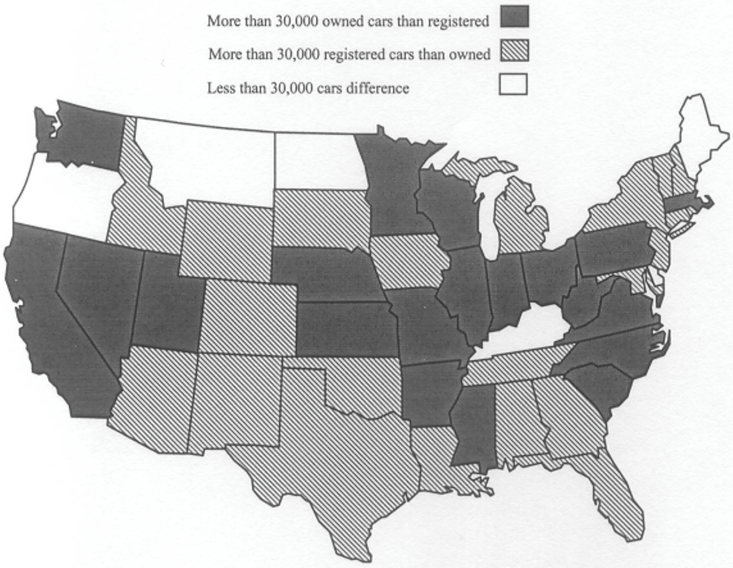
In South America, Uruguayan states are found to behave strategically when setting car registration fees. Gandelman (2000) finds statistical evidence suggesting that differences in

[1] Star Tribune, January 3 1999.

[2] January 28 and April 6, 1999.

[3] Registration data were obtained from Highway Statistics 1990, and are based on states' registration records. The number of cars owned by households was obtained from the reports to the 1990 Census of Population and Housing. We computed the difference between these two series.

Figure 1: Owned Cars vs Registered Cars by State



community sizes and income distribution are relevant in determining the outcomes. Montevideo, by far the largest community, has historically set higher fees than other municipalities. In 1995, traffic inspectors controlled the main street access to downtown Montevideo and found that 40% of the cars were from other communities. Maldonado, a small municipality, seems to have received an important share of tax evaders over the years. In 1985, the people per registered car ratio in Montevideo and Maldonado was 8.7 and 6.1 respectively. During the following ten years Uruguay opened its economy, and the consumption of cars increased. By 1996, the people per car ratio in Montevideo had decreased to 7.1, while in Maldonado it had fallen to 3.2. The different municipalities have since then signed cooperation agreements in setting registrations fees, but local governments have continued competing with various discount schemes for tax payments. The only community that has rejected the agreements and has continued fixing lower fees is the smallest of all communities.

The outline of this chapter is as follows: we introduce the model in section 2, and the agents' decision problem in section 3. We state the game between the local governments and define an equilibrium concept in section 4. In section 5 we characterize the properties of pure strategy equilibria for identical and different communities. We analyze the optimal monitoring policy of a high-tax location in section 6; we then conclude in section 7.

2 The Model

There are two communities, each populated by a continuum of agents who differ in levels of income y that is measured in units of a private consumption good. Income distribution in each community is defined on the support $[\underline{y}, \overline{y}]$ and is characterized by a continuous density function $\psi_i(y) = N_i\phi_i(y)$, where $\int \phi_i(y)dy = 1$ and $N_i > 0$ denotes the population size. We use Φ_i to denote the cumulative distribution function of the density ϕ_i. Communities may thus differ in two dimensions: income distribution and population size.

Individuals in each community have preferences over net income. We assume that the utility function, u, representing preferences, satisfies $u' > 0$, $u'' < 0$, and decreasing absolute risk aversion (henceforth referred to as DARA).

Local governments fix residence-based head taxes, T_i. Local governments can verify if individuals contribute or not, but not if they do it where they are supposed to, because agents may choose to declare residence in the neighboring community, if it requires a lower tax, and pay taxes there. If an individual decides to evade taxes he takes into account the local government's monitoring efforts, represented as a constant probability of being caught, $\pi \in (0, 1)$. The penalty for evasion is having to pay a constant fine, F. Fines could be different across communities, but we assume they are not choice variables (presumably, they are imposed by a federal authority). We assume fines are the same across locations for simplicity.

Local governments are Leviathans: their objective is to maximize revenues from taxation and penalties from perpetrators that are caught.

The model describes competition among communities for fiscal revenue by means of a non-cooperative two-stage game. In the first stage local governments announce taxes and fine policies and in the second stage individuals make decisions on where to pay taxes.

3 Decision Problem of Individuals

Given announced policies in both communities (T_1, T_2), individuals have to decide whether to pay taxes at home or lie about their place of residence and pay taxes in the rival location. In what follows, we assume that the monitoring technology is the same across locations. An individual of community 1 with income y derives utility $u(y - T_1)$ if he decides to pay at home. If he lies, his expected utility is $(1 - \pi)u(y - T_2) + \pi u(y - T_2 - F)$.

Remark 1 *A necessary condition for tax evasion is $T_2 < T_1$. A sufficient condition is $T_2 + F \leq T_1$.*

Clearly, the interesting case to discuss is when $T_2 < T_1 < T_2 + F$, since we may have $u(y - T_1) \lesseqgtr (1-\pi)u(y-T_2) + \pi u(y - T_2 - F)$. The following Proposition refers to this case.

Proposition 1 *For any configuration of taxes (T_1, T_2), and for each community i, there exists a unique cut-off income level, $y_i^* \in [\underline{y}, \overline{y}]$, such that every agent in community i with $y \geq y_i^*$ decides to evade, and those with $y < y_i^*$ decide not to.*

Proof. Examine the problem of an agent in community 1. For any $y \in [\underline{y}, \overline{y}]$, define $c(y, T_2)$ to be the certainty equivalent of the evasion lottery, i.e., the level of net income such that $u(c(y,T_2)) = (1-\pi)u(y-T_2) + \pi u(y-T_2-F)$. An agent with income y will not evade if and only if $u(y - T_1) > (1-\pi)u(y-T_2) + \pi u(y-T_2-F)$; by the definition of $c(y, T_2)$, this is equivalent to requiring that $y - c(y, T_2) > T_1$. Since u satisfies DARA, $y - c(y, T_2)$ is strictly decreasing in y, and $\check{y}$, such that $\check{y} - c(\check{y}, T_2) = T_1$, is unique when it exists. Define y_1^* by:

$$y_1^* = \begin{cases} \underline{y} & \text{if } \ \underline{y} - c(\underline{y}, T_2) \leq T_1 \\ \overline{y} & \text{if } \ \overline{y} - c(\overline{y}, T_2) \geq T_1 \\ \check{y} & \text{if } \ \underline{y} - c(\underline{y}, T_2) > T_1 \text{ and } \overline{y} - c(\overline{y}, T_2) < T_1. \end{cases} \tag{3.1}$$

Thus y_1^* is unique and satisfies the required properties; y_2^* is defined analogously. ∎

We can have three cases shown in Figure 2.[4] In case B there is no tax evasion, in case C everybody evades, and in case A only the rich do. The individual with income level $y = y^*$ is indifferent. If $y^* = \overline{y}$ there is no tax evasion. According to this Proposition, if in equilibrium there is any tax evasion in a community, it is the rich agents who evade. This result is analogous to the spatial competition models of Kanbur and Keen (1993) and Ohsawa (1999), in which individuals with the lowest transportation cost, i.e., those closest to the border, are the ones more likely to evade.

The cut-off levels y_i^* satisfy the following:

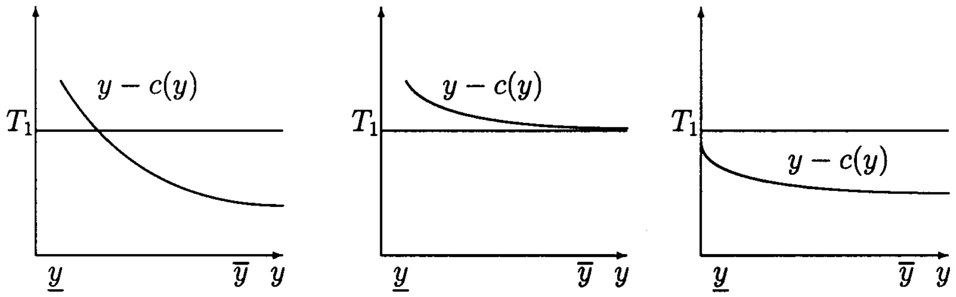
Proposition 2 *$y_i^*(T_i, T_j)$ is non increasing in T_i and non decreasing in T_j.*

Proof. It is enough to proof the result for an interior $y_i^* \in (\underline{y}, \overline{y})$. In this case, the Implicit Function Theorem implies that y_i^* is continuous and differentiable, and we have:

$$\frac{\partial y_i^*(T_i, T_j)}{\partial T_i} = \frac{u'(y^* - T_i)}{u'(y^* - T_i) - (1-\pi)u'(y^* - T_j) - \pi u'(y^* - T_j - F)} < 0.$$

[4] Given that $u' > 0$, by the Inverse Function Theorem, u^{-1} exists and is differentiable, thus c is continuous and differentiable in y.

Figure 2: Evasion Decisions

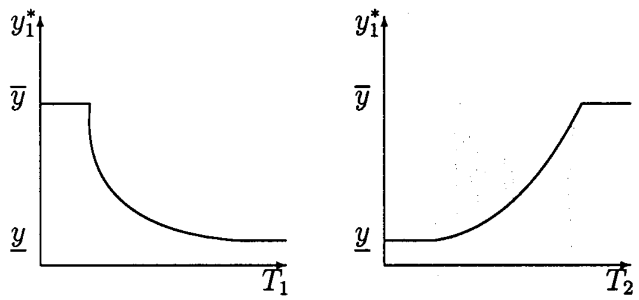


Case A: The Rich Evade Case B: Nobody Evades Case C: Everybody Evades

The sign follows because the numerator is positive and the denominator is negative by Lemma 1 in the Appendix.

We can show that $\frac{\partial y_i^*(T_i,T_j)}{\partial T_j} > 0$ in the same manner. ∎

Figure 3: Characterization of y_1^*



Intuitively, when the tax difference is larger, poorer agents can afford to take the risk of evading. If the gains from evasion are small, only the richest people will be able to afford choosing the implied lottery of tax evasion. See Figure 3. Clearly, if taxes coincide there is no incentive to evade.

4 Game between local governments

Local governments set their taxes strategically in a two stage game. In the first stage, they announce their policies; in the second stage, individual decisions on tax evasion determine the tax base in each community.

The solution concept is subgame perfection. An equilibrium is characterized by backward induction replacing the decision rules of individuals—represented by cut-off levels of income y_1^*—in the objective functions of the local governments. The values y_i^* determine who evades taxation in each location. The tax base is formed by local agents who do not evade and foreign agents who evade in their community of origin. In addition, fines are collected from local agents who evade and are caught; by the law of large numbers, they represent a fraction π of tax evaders.

The revenue function of local government 1 is given by the following expression:

$$R_1\left(T_1, T_2\right) = \begin{cases} \{N_1 + N_2[1 - \Phi_2(y_2^*(T_1, T_2))]\}T_1 & \text{if } \; T_1 \leq T_2 \\ N_1\Phi_1(y_1^*(T_1, T_2))T_1 + \pi F N_1[1 - \Phi_1(y_1^*(T_1, T_2))] & \text{if } \; T_1 \geq T_2, \end{cases} \tag{4.1}$$

where $\Phi_i(y_i^*)$ is the fraction of individuals that evade taxes in community i.

Definition 1 *A pure strategy equilibrium for this economy is a tax for each community* T_i, *and cut-off income levels* $y_i^*(T_i, T_j)$, *for* $i = 1, 2$, *and* $j \neq i$, *such that:*
i) T_i *solves the problem of community* i *given the policy of the other community* T_j, *and aggregate decision rules, summarized by cut-off levels* $y_i^*(T_i, T_j)$ *and* $y_j^*(T_j, T_i)$,
ii) income levels $y_i^*(T_i, T_j)$ *and* $y_j^*(T_j, T_i)$ *are determined consistently with individual decision problems, when residents take policies* (T_i, T_j) *as given.*

The above definition of equilibrium corresponds to the Nash equilibrium of the reduced game defined by incorporating agents' best response to announced governments' policies in the payoff functions of the local governments: $\Gamma_N = [I, \{S_i\}, \{R_i\}]$, where $I = \{1, 2\}$ is the set of communities or local governments; $S_i = [0, \overline{T}] \subset \Re$ is the set of strategies for local government i, and R_i is the payoff defined in equation (4.1).[5] It is easy to see that the objective functions in our problem need not be concave because of the endogenous determination of the tax base. In such cases, there are no general results guaranteeing existence of pure strategy equilibria. However, mixed strategy equilibria are shown to exist, for example in Dasgupta and Maskin (1977) under continuity alone. In our case, the objective

[5]Notice that given the structure of the model, in order to guarantee non-negativity of net income for the lowest income type, we have to define a maximal tax $\overline{T} < \underline{y}$.

function R_i will be continuous if the cut-off levels y_i^* are and the income distribution function has no mass points. In the appendix we prove this is the case.

In what follows we will examine properties of pure strategies equilibria when they exist, in particular, the way policies determine the mobility of the tax base through the tax evasion decisions of individuals.

5 Size and Income Effects on Policies

In the model, communities may differ in two dimensions: size and income distribution. In this section, we ask whether small communities set lower taxes in equilibrium. In order to isolate the effects of differences in community size, we assume equal income distributions $\phi_i = \phi$, and allow for differences in total mass, N_i. It turns out that having a smaller population allows locations to gain by undercutting the rival's tax rate and attracting a large mass of evaders. The large location, in contrast, has more to lose by attempting to undercut the smaller rival because of its own large base.

We also examine the effects of differences in income, normalizing $N_1 = N_2 = 1$ and allowing the functions ϕ_i to vary. We define community 1 to be richer than community 2 if the implied cumulative distribution function of community 1 dominates the distribution of 2 in the first order stochastic sense.[6] It turns out, however, that a clear characterization, as in the case of size differences, cannot be obtained.

5.1 Size Differences

5.1.1 Identical communities: $N_1 = N_2$

With identical communities we could imagine that an asymmetric situation could be an equilibrium: for example, one community sets lower taxes and attracts the top portion of the population of the rival community, which sets a higher tax on its reduced base. In equilibrium with equally sized communities, however, taxes cannot differ "too much" as

[6] Community 1 is richer than community 2 if

$$\int_{\underline{y}}^{x} \phi_1(y)dy \leq \int_{\underline{y}}^{x} \phi_2(y)dy \text{ for all } x \in [\underline{y}, \overline{y}]$$

i.e.

$$\Phi_1(x) \leq \Phi_2(x) \text{ for all } x \in [\underline{y}, \overline{y}].$$

stated in Proposition 3. In fact, as shown in Proposition 4, with identical communities there cannot be an asymmetric equilibrium in pure strategies.

Proposition 3 *If $N_1 = N_2$, then in any equilibrium in pure strategies $|T_1 - T_2| \leq \pi F$.*

Proof. Without loss of generality let $T_1 \geq T_2$. If (T_1, T_2) is an equilibrium, it must be the case that:

$$\begin{aligned} R_1(T_1, T_2) &\geq R_1(T_2, T_2) \\ R_2(T_2, T_1) &\geq R_2(T_1, T_1). \end{aligned} \tag{5.1}$$

Adding both inequalities we get

$$N\Phi_1(y_1^*(T_1, T_2, F))T_1 + N[1 - \Phi_1(y_1^*(T_1, T_2, F))]\,[\pi F + T_2] + NT_2 \geq NT_1 + NT_2,$$

this in turn implies

$$[1 - \Phi_1(y_1^*(T_1, T_2, F))]\,[\pi F + T_2] \geq [1 - \Phi_1(y_1^*(T_1, T_2, F))]T_1, \tag{5.2}$$

and finally,

$$T_1 - T_2 \leq \pi F.$$

■

Proposition 4 *If $N_1 = N_2$, there cannot be an equilibrium (T_1, T_2) with $T_1 \neq T_2$.*

Proof. Suppose there is an equilibrium with $T_1 > T_2$. Proposition 3 tells us that $T_1 - T_2 \leq \pi F$ holds in this case, but then $y - T_2 - \pi F \leq y - T_1$, which implies that for any individual in community 1, the expected payoff to evading taxes is less than the payoff to paying taxes at home:

$$(1 - \pi)(y - T_2) + \pi(y - T_2 - F) \leq y - T_1.$$

Risk aversion then implies that

$$u(y - T_1) \geq (1 - \pi)u(y - T_2) + \pi u(y - T_2 - F),$$

and no individual in either jurisdiction would choose to evade. Hence, it would pay jurisdiction 2 to raise its tax, a contradiction. ■

It turns out that the only possibility for equilibria in pure strategies with identical communities is the one in which governments set maximal taxes, as implied by the next Proposition.

Proposition 5 *Assume $F > 0$ and $\pi > 0$. If there exists a symmetric equilibrium in pure strategies (T, T) it must be that $T = \overline{T}$.*

Proof. Suppose (T, T) is an equilibrium and $T < \overline{T}$. In this situation there is no evasion, since for any agent with income y in either community:

$$u(y - T) > (1 - \pi)u(y - T) + \pi u(y - T - F).$$

Because the inequality is strict, either community can slightly increase its tax without inducing any evasion and increase its revenue. Therefore (T, T) could not have been an equilibrium. ■

The difficulty in finding equilibria where tax rates are not maximal lies in the assumption that all individuals must pay taxes. If local governments allowed individuals for whom net income became negative to be exempt from taxation, we could find pure strategy equilibria where taxes fell below the highest income level. This extension requires using exceptional qualifications for tax evaders; for example, when an individual is only constrained if he gets caught.

5.1.2 Different communities: $N_1 > N_2$

Casual evidence suggests that larger (or more densely populated) communities tend to set higher taxes. Smaller communities, by fixing a lower tax, can generate extra revenue collected from tax evaders attracted from the rival community—at the cost of losing revenue from the local population. Intuitively, small communities have more to gain from attracting a larger mass of tax evaders, because the density of their own tax base is small. Our model produces the following result: when community sizes differ, the larger community does not set the lower tax.

Theorem 1 *When locations differ in size, the large community will not set the smaller tax, i.e., $(N_1 - N_2)(T_1 - T_2) \geq 0$.*

Proof. Let $\theta = N_1/N_2$. Consider the following cases:
Case 1: $T_1 < T_2$.

In equilibrium we must have,

$$\begin{aligned} R_1(T_1, T_2) &\geq R_1(T_2, T_2) \\ R_2(T_2, T_1) &\geq R_2(T_1, T_1). \end{aligned} \tag{5.3}$$

Expanding we can express these inequalities as:

$$\begin{aligned} \theta T_1 + T_1[1 - \Phi(y_2^*(T_2, T_1))] &\geq \theta T_2 \\ T_2\Phi(y_2^*(T_2, T_1)) + \pi F[1 - \Phi(y_2^*(T_2, T_1))] &\geq T_1. \end{aligned}$$

Adding the expressions and manipulating we obtain,

$$(\theta - 1)(T_1 - T_2) \geq (T_2 - T_1 - \pi F)[1 - \Phi(y_2^*(T_2, T_1))]. \tag{5.4}$$

Case 2: $T_1 > T_2$.
The same inequalities imply in this case:

$$\begin{aligned} \theta T_1\Phi(y_1^*(T_1, T_2)) + \pi F\theta[1 - \Phi(y_1^*(T_1, T_2))] &\geq \theta T_2 \\ T_2 + T_2\theta[1 - \Phi(y_1^*(T_1, T_2))] &\geq T_1. \end{aligned}$$

Adding the expressions and manipulating again:

$$(\theta - 1)(T_1 - T_2) \geq (T_1 - T_2 - \pi F)\theta[1 - \Phi(y_1^*(T_1, T_2))]. \tag{5.5}$$

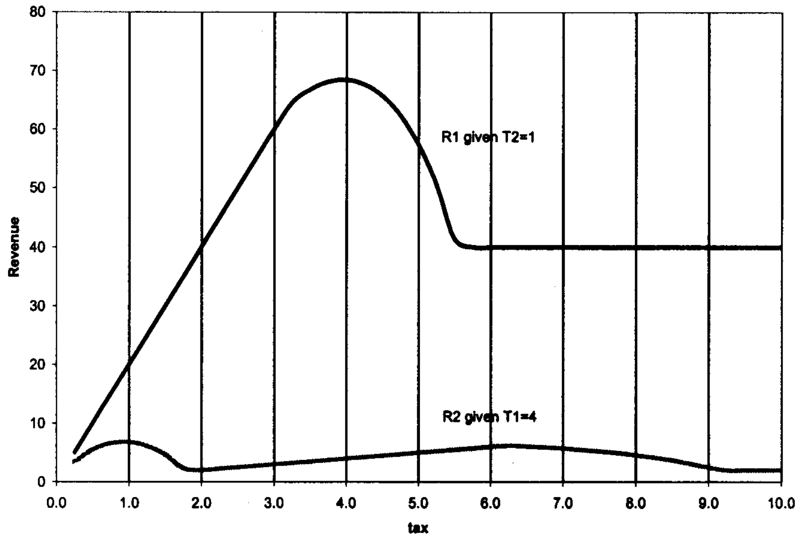
The argument in Proposition 4 implies that when $T_1 \neq T_2$ in equilibrium, we must have $|T_1 - T_2| > \pi F$, and the result follows, since $(1 - \Phi(y_i^*)) \geq 0$. ■

In Figure 4 we present the revenue functions of a small and large community in a parameterization in which a pure strategy equilibria exists, and the small community sets the lower tax rate. Furthermore, the higher tax rate is not maximal.

5.2 Income Differences

When communities differ in income there are two opposing effects. Consider the case with one poor and one rich community. Take the tax of the rich community as given. The poor community by fixing a lower tax can attract the top portion of the rich community,

Figure 4: Differences in size: $N_1 > N_2$



which may represent a sizeable increase in tax base—a stealing effect—but it can also set a higher tax, knowing that its local agents are poor and will probably not take the chances of getting caught—a capturing effect—thereby increasing local revenues. In general, it is not possible to determine which effect dominates, as the next example shows.

Example 1 If one of the communities has a degenerate income distribution, in equilibrium, it will set the lower tax.

Proof. Let community 1 have a degenerate distribution at some income level $\widehat{y}_1$. Suppose there is an equilibrium with $T_1 > T_2$.

i) In any equilibrium situation there cannot be any tax evasion in community 1.

Since all individuals are identical, tax evasion would imply that everyone evades and revenues would be zero. The government in location 1 could then increase revenues by setting the same tax as the rival community.

ii) Now, because there is no evasion in community 1, $R_2(T_1, T_2) = T_2 < R_2(T_1, T_1) = T_1$, a contradiction. ■

Note that we made no assumption on the income level of community 1. In particular the last results holds if $\widehat{y}_1 = \overline{y_2}$ or $\widehat{y}_1 = \underline{y_2}$ (if everyone in community 1 is as rich as the richest agent of community 2 or as poor as the poorest agent in community 2).

6 Optimal Monitoring

Monitoring determines the risk that individuals face in the case of evasion. When monitoring is less stringent, communities face a more elastic tax base, which implies tougher competition. Local governments respond by lowering taxes to reduce the incentives to evade. In the extreme case of no monitoring effort, undercutting may lead to destructive competition. Intuitively, if either the probability of getting caught or the penalties are fixed equal to zero across locations, whenever taxes differed, everyone would choose to evade in the high-tax location. Thus in equilibrium taxes would have to be equal because the tax base is perfectly mobile. Undercutting—in a Bertrand competition spirit—then would drive tax rates to zero. Revenue collection in such case, would be zero in each community.

Until now the probability of getting caught was treated as a parameter of the model. It is possible to argue that this is also a policy instrument for the local communities.[7] In what follows we assume there is a per capita cost of monitoring, given by an increasing function m. We consider situations in which communities have already committed to a tax policy, and now have to choose optimal monitoring.

We assume $T_1 > T_2$ and $T_1 < T_2 + F$ so that is possible to induce at least some agents not to evade. Clearly, community 2 will not monitor because it has the lower tax, so the focus is on community 1.

6.1 Homogenous Monitoring

Suppose local governments are not able to set different levels of monitoring in terms of income level. In this situation, given the fixed taxes in each community, local revenues as a function of the monitoring probability are given by:

$$R_1(\pi; T_1, T_2) = N_1\Phi_1(y_1^*(\pi; T_1, T_2))T_1 + \pi F N_1[1 - \Phi_1(y_1^*(\pi; T_2, \pi))] - N_1 m(\pi). \quad (6.1)$$

The optimal level of monitoring is characterized by the following first order condition:

$$[T_1 - \pi F]\,\phi_1(y_1^*(T_1, T_2, F, \pi))\frac{\partial y^*}{\partial \pi} + F[1 - \Phi_1(y_1^*(\pi; T_2, \pi))] = \frac{\partial m(\pi)}{\partial \pi}, \quad (6.2)$$

[7] In the 1998 agreement between communities in Uruguay, taxes were fixed for each location, and the only variable still in control of local governments was their monitoring effort.

where the response of the cut-off level y_1^* to changes in the probability of being caught is:

$$\frac{\partial y_1^*}{\partial \pi} = \frac{u(y_1^* - T_2 - F) - u(y_1^* - T_2)}{u'(y_1^* - T_1) - (1-\pi)u'(y_1^* - T_2) - \pi u'(y_1^* - T_2 - F)} < 0. \tag{6.3}$$

The left hand side in (6.2) shows the marginal benefit of increasing the level of monitoring. The first term indicates the net marginal gain from having evaders pay taxes instead of fines, and the second term is the increase in fines collected from perpetrators that are now more likely to get caught. The right hand side represents the marginal cost of increasing the level of monitoring.

The next example illustrates the case of a high-tax community optimally choosing a monitoring policy. Notice that it is optimal for this community to allow some level of evasion. In Figure 5 we show the revenues as a function of the probability π.

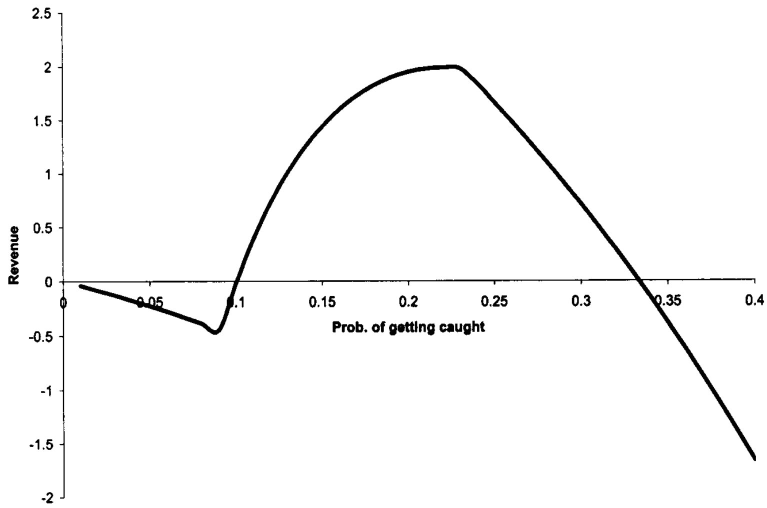
- $N_1 = N_2 = 1$
- $\phi_1(y) = \phi_2(y) = \left(\frac{\overline{y}\underline{y}}{\overline{y}-\underline{y}}\right)\frac{y}{y^2}$ with $\underline{y} = 10$ and $\overline{y} = 150$
- $u(y) = \frac{1}{b-1}(a+by)^{1-\frac{1}{b}}, a = 2, b = 0.2$
- $m(\pi) = 10\frac{\pi}{(1-\pi)}$
- $F = 6$, $T_1 = 5$, $T_2 = 3.5$

In this community, the optimal monitoring policy, $\pi = 0.2208$, results in an income cut-off value of $y_1^* = 89.54$. Given the Pareto distributions we assumed, this implies that the top 4.82% of agents in community 1 decides to evade taxation.

6.2 Differentiated Monitoring

It is desirable to analyze the possibility of having monitoring depend on income levels. If it were possible to implement such a policy, it is clear that there must be a positive level of monitoring for all income levels in the high-tax community, since otherwise whoever is not monitored will evade. To get some intuition consider initially a fixed monitoring policy π, which results in an interior cut-off income level y_1^*. The local government may increase net revenues by changing to a variable monitoring policy $\pi(y)$. A variable policy would allow the government to lower costs of monitoring agents with income levels below y_1^*, without inducing them to evade, but it would be costly to induce agents with incomes above y_1^* not to evade. The optimal monitoring policy for each income level is obtained comparing the

Figure 5: Optimal homogeneous monitoring



net benefits of collecting taxes or expected fines from that individual. Intuitively, there may exist an income level $\widehat{y}_1$ such that it does not pay location 1 to prevent agents with $y \geq \widehat{y}$ from evading. The local government should set the monitoring policy for these agents to maximize expected revenue from fines.

In the region of income levels where the government induces compliance, it will maximize the difference between tax and monitoring costs per individual, subject to inducing agents to pay taxes at home. The optimal policy in this region is obtained with a constrained cost minimization problem.

In the region of income levels where the government allows evasion to collect fines, it will maximize the difference between fines and costs of monitoring agents who choose to evade.

We show in the following paragraphs that in the region of compliance the net benefit from collecting taxes, $T - m(\pi^T(y))$, is decreasing in y. In the region of avoidance, the monitoring policy of evaders, π^F, will not depend on income, and the net benefit will be constant.

Proposition 6 *There exists a cut-off level of income $\hat{y}$ such that the optimal monitoring policy for community 1 takes the following form:*

$$\pi(y) = \begin{cases} \pi^T(y) & = & \frac{u(y-T_2)-u(y-T_1)}{u(y-T_2)-u(y-T_2-F)} & \text{if } y \leq \widehat{y} \\ \pi^F & = & m'^{-1}(F) & \text{if } y \geq \widehat{y}. \end{cases}$$

Proof.
Step 1. In the compliance region, since monitoring is costly, the local government will not monitor in excess. The government sets $\pi(y)$ in this region, such that:

$$u(y-T_1)-(1-\pi^T(y))u(y-T_2)-\pi^T(y)u(y-T_2-F)=0.$$

Thus

$$\pi^T(y)=\frac{u(y-T_2)-u(y-T_1)}{u(y-T_2)-u(y-T_2-F)}.$$

This expression is increasing in income:

$$\begin{aligned}\frac{\partial\pi^T(y)}{\partial y} &= \frac{[u'(y-T_2)-u'(y-T_1)]\,[u(y-T_2)-u(y-T_2-F)]}{[u(y-T_2)-u(y-T_2-F)]^2} \\ &\quad -\frac{[u(y-T_2)-u(y-T_1)]\,[u'(y-T_2)-u'(y-T_2-F)]}{[u(y-T_2)-u(y-T_2-F)]^2} \\ &> \frac{[u'(y-T_2)-u'(y-T_1)]\,[u(y-T_2)-u(y-T_2-F)]}{[u(y-T_2)-u(y-T_2-F)]^2} \\ &\quad -\frac{[u'(y-T_2)-u'(y-T_2-F)]\,[u(y-T_2)-u(y-T_2-F)]}{[u(y-T_2)-u(y-T_2-F)]^2} \\ &= \frac{[u'(y-T_2-F)-u'(y-T_1)]\,[u(y-T_2)-u(y-T_2-F)]}{[u(y-T_2)-u(y-T_2-F)]^2}>0.\end{aligned}$$

Step 2. In the avoidance region, the optimal monitoring policy solves:

$$\max_{\pi^F(y)} N_1\int_{\hat{y}}^{\overline{y}}\left[\pi^F(y)F-m\left(\pi^F(y)\right)\right]\phi_1(y)dy.$$

The first order condition,

$$F=m'\left(\pi^F(y)\right),$$

implies that $\pi^F=m'^{-1}(F)$ is constant.
Step 3. In order to find the level $\widehat{y}$ above which the government allows evasion, the following

problem is solved:

$$\max_{\widehat{y}} \int_{\underline{y}}^{\widehat{y}} [T - m(\pi^T(y))]\, \phi(y)dy + \int_{\widehat{y}}^{\overline{y}} [\pi^F F - m(\pi^F)]\phi(y)dy.$$

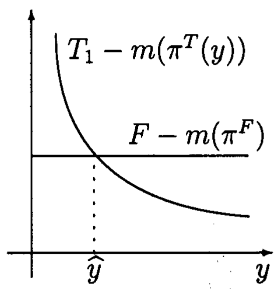
The first order condition is given by:

$$T - m(\pi^T(\widehat{y})) = \pi^F F - m(\pi^F).$$

The left hand side is the net marginal benefit from compliance, and it is a strictly decreasing function of y. The right hand side is the net marginal benefit from expected fines in the avoidance region, and it is a constant function. The level $\widehat{y}$ is thus uniquely defined. ■

The determination of the cut-off level $\widehat{y}$ is shown in Figure 6.

Figure 6: Determination of $\widehat{y}$



7 Conclusion

The model developed in this chapter examines tax competition in a framework with residence-base taxation in which authorities can only imperfectly monitor the origin of tax payers who may choose to evade local taxation by pretending to be residents of the rival low-tax community. We characterize the properties of equilibria in pure strategies when communities differ in size, and find that small communities have advantages in capturing tax base from their rival by undercutting their higher tax rate. We exploit one example to show that differences in communities' income levels alone yield no clear prediction with respect to tax policies chosen by rival communities.

In our analysis we ignore the issue of tax harmonization. Existing results in the literature in this respect are mixed, and depend on the kind of harmonization that is adopted. Our model clearly indicates that integration, in the sense of joint revenue maximization would be beneficial from the perspective of local governments.

We also characterize the problem facing individual residents who evaluate the payoffs of complying with local taxation and the resulting lottery of evasion. Decreasing risk aversion implies that only high income agents can afford to choose the evasion lottery. This feature is comparable to existing modeling strategies in spatial frameworks of cross-border shopping, where risk-neutral individuals have unit demands, and valuation net of costs of transportation replaces our definition of income.

We show that it may be optimal for a high-tax community to allow some people to evade and that the monitoring policy should be increasing over the compliance region and constant over the avoidance region. In our framework, lump-sum tax policies imply that relatively less risk-averse agents can avoid high taxes by fleeing to another community. This feature makes the head tax structure regressive. Presumably, a federal authority in charge of choosing an optimal tax structure would take into account attitudes toward risk.

The implications of the model seem to be in line with some preliminary evidence for Uruguay and with casual evidence for some regions of the US. In particular, Gandelman (2000) finds statistical correlation between community size and the distribution of car values across municipalities, and between size and magnitude of registration fees.

In a more general analysis of policy coordination, particularly between countries, it would be interesting to study the full version of the game where both tax and monitoring policies can be used strategically. Presumably, even when some type of coordination can be achieved with respect to tax policies, harmonization of monitoring efforts is more difficult.

Another question that arises regarding integration of countries is whether allowing for population migration implies some kind of sorting result. In such a framework, we could study the different implications of having closed borders to household migration, as we have done in our model, and opening borders so that individuals who migrate no longer are considered tax evaders. Traditional models of migration of heterogeneous population obtain stratification results in terms of income; in an environment with migration costs, individuals would face the options of evading taxation or emigrating to the low tax country, which might prevent stratification.

References

Census of Population and Housing, Bureau of the Census. US Department of Commerce Economics and Statistics Administration, 1990.

Highway Statistics, Federal Highway Administration. US Department of Transportation. Washington, D. C., 1990.

A Study of Improper Motor Vehicle Registrations, The Commonwealth of Massachusetts. Office of the Inspector General, March 1997.

Allingham, M. G and A. Sandmo, "Income Tax Evasion: A Theoretical Analysis," *Journal of Public Economics*, 1972, *1*, pp. 323–338.

Beard, T. Randolph, Paula A. Gant and Richard P. Saba, "Border-Crossing Sales, Tax Avoidance, and State Tax Policies: An Application to Alcohol," *Southern Economic Journal*, Jul 1997, *64*(1), pp. 293–306.

Bucovetsky, S., "Asymmetric Tax Competition," *Journal of Urban Economics*, 1991, *30*, pp. 167–181.

Crawford, Ian and Sarah Tanner, "Bringing It All Back Home: Alcohol Taxation and Cross-Border Shopping," *Fiscal Studies*, May 1995, *16*(2), pp. 94–114.

Dasgupta, P. and E. Maskin, "The Existence of Equilibrium: Continuity and Mixed Strategies," Technical Report 252, Standford University, 1977.

Gandelman, Néstor, *Essays in Community Models and R&D Institutional Arrangements*, Ph.D. thesis, University of Rochester, Rochester, N. Y., 2000.

Gordon, Roger H. and Soren Bo Nielsen, "Tax Evasion in an Open Economy: Value Added Vs. Income Taxation," *Journal of Public Economics*, 1997, *66*(2), pp. 173–197.

Kanbur, Ravi and Michael Keen, "Jeux Sans Frontieres: Tax Competition and Tax Coordination When Countries Differ in Size," *American Economic Review*, Sep 1993, *83*(4), pp. 877–892.

Ohsawa, Yoshiaki, "Cross-Border Shopping and Commodity Tax Competition Among Governments," *Regional Science and Urban Economics*, 1999, *29*, pp. 33–51.

Saba, Richard P., T. Randolph Beard, Robert B. Ekelud, Jr. and Rand W. Ressler, "The Demand for Cigarette Smuggling," *Economic Inquiry*, Apr 1995, *XXXIII*, pp. 189–202.

Wilson, John D., "Tax Competition with Interregional Differences in Factor Endowments," *Regional Science and Urban Economics*, 1991, *21*, pp. 423–451.

Appendix

Define

$$U(y,T_1,T_2) = u(y-T_1) - (1-\pi)u(y-T_2) - \pi u(y-T_2-F).$$

Lemma 1 *If (T_1,T_2) are policies such that $y_1^*(T_1,T_2) \in (\underline{y},\overline{y})$, then* $\left.\frac{\partial U(y,T_1,T_2)}{\partial y}\right|_{y=y_1^*} < 0$.

Proof. Note that $U(y_1^*,T_1,T_2) = 0 \Leftrightarrow y_1^* - c(y_1^*,T_1,T_2) = T_1$.
The assumption of DARA implies $\frac{\partial y - c(y,T_1,T_2)}{\partial y} < 0$, and therefore $\frac{\partial c(y,T_1,T_2)}{\partial y} > 1$. From the definition of $c(y,T_1,T_2)$, we have $u'(c(y,T_1,T_2))\frac{\partial c(y,T_1,T_2)}{\partial y} = (1-\pi)u'(y-T_2)+\pi u'(y-T_2-F)$, which implies $(1-\pi)u'(y-T_2) + \pi u'(y-T_2-F) > u'(c(y,T_1,T_2))$ for all y.
Finally we have:

$$\begin{aligned}\left.\frac{\partial U(y,T_1,T_2)}{\partial y}\right|_{y=y_1^*} &= u'(y_1^*-T_1) - (1-\pi)u'(y_1^*-T_2) - \pi u'(y_1^*-T_2-F) \\ &< u'(y_1^*-T_1) - u'(c(y_1^*,T_1,T_2)) = 0.\end{aligned}$$

The last equality follows from the definition of $c(y,T_1,T_2)$ and y_1^* interior. ■

Let $\Upsilon_1(T_2,F_1) = \{T_1 : y^*(T_1,T_2,F_1) \in (\underline{y},\overline{y})\}$ and
$\Upsilon_2(T_1,F_1) = \{T_2 : y^*(T_1,T_2,F_1) \in (\underline{y},\overline{y})\}$. Let $\underline{\tau_1} = \inf \Upsilon_1$, $\overline{\tau_1} = \sup \Upsilon_1$, $\underline{\tau_2} = \inf \Upsilon_2$ and $\overline{\tau_2} = \sup \Upsilon_2$.

Lemma 2 .

a) For fixed T_2, F_1 it is the case that $y^*(\underline{\tau_1},T_2,F_1) = \overline{y}$ and $y^*(\overline{\tau_1},T_2,F_1) = \underline{y}$.

b) For fixed T_1, F_1 it is the case that $y^*(T_1,\underline{\tau_2},F_1) = \underline{y}$ and $y^*(T_1,\overline{\tau_2},F_1) = \overline{y}$.

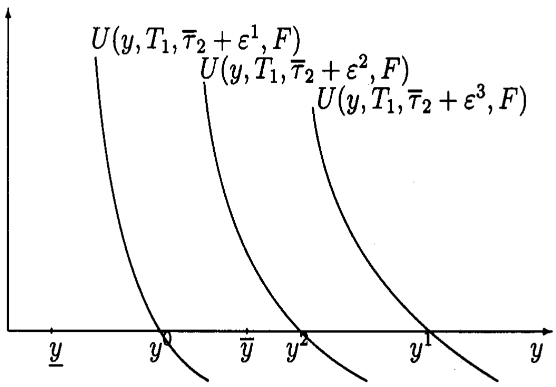
Proof. (By contradiction) We will prove part b). The proof of part a) follows the same steps.

b) From the previous lemma we know that if there exists an interior y^* then $U(\cdot,T_1,T_2,F_1)$ is decreasing in y.

Suppose that $U(y, T_1, \overline{\tau_2}, F_1) = 0$ for $y < \overline{y}$, call this y, y^0. By definition of $\overline{\tau_2}$, for any small $\varepsilon^1 > 0$, $U(y, T_1, \overline{\tau_2}+\varepsilon^1, F_1) = 0$ for some $y > \overline{y}$ call this y, y^1. But then if we let $\varepsilon^2 = \frac{\varepsilon^1}{2}$ we have that $U(y, T_1, \overline{\tau_2} + \varepsilon^2, F_1) = 0$ for some $y^2 \in (\, y^0,\, y^1)$. If $y^2 \leq \overline{y}$ then $\overline{\tau_2}$ is not the supremum of Υ_2 and we have a contradiction; if $y^2 > \overline{y}$, we define $\varepsilon^3 = \frac{\varepsilon^1}{3}$ and continue in the same fashion, since the sequence $\{y^k\}$ converges to $y^0 < \overline{y}$ when $k \to \infty$ (since $\varepsilon^k \to 0$); this gives a contradiction and therefore $y^*(T_1, \overline{\tau_2}, F_1) = \overline{y}$. Figure 7 illustrates the reasoning.

To show $y^*(T_1, \underline{T_2}, F_1) = \underline{y}$ we follow an analogous reasoning. ■

Figure 7: Graph for Lemma 2



Proposition 7 *The cut-off level y_1^* defined in equation (3.1) is continuous in* (T_1, T_2).

Proof. Given Lemma 2, it is enough to show continuity for policies (T_1, T_2) such that $y_1^* \in (\underline{y}, \overline{y})$. Given policies (T_1, T_2) an agent with income y in community 1 decides to evade if $U(y, T_1, T_2) < 0$. Since

$$\left.\frac{\partial U(y, T_1, T_2)}{\partial y}\right|_{y=y_1^*} < 0$$

by Lemma 1, the Implicit Function Theorem implies that the function $y^*(T_1, T_2)$ such that $U\left(y^*\left(T_1, T_2, F\right), T_1, T_2, F\right) = 0$ is continuous in the set of policies (T_1, T_2). ■