Community Tax Competition¤

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Abstract

This paper examines a multi community environment where local authorities compete for tax base. It is often the case that it is easy to monitor if agents paid taxes or not but it is more difficult to monitor if they contributed where they were supposed. In that event agents may decide to cross borders and pay in a neighbor community (evasion), saving the tax difference.

In the literature of fiscal competition in general it is assumed that agents are mobile, but once they choose their community of residence they obey the law and pay taxes there. Alternatively we could think that moving to a different community is extremely costly and agents may decide not to move but evade taxes. One contribution of this paper is a model in which the decision where to pay taxes is endogenous to the tax rates and the local authorities incorporate that into their decision.

First we present a model were evaders face a probability of getting caught in which case they have to pay a fine. In this framework to evade is equivalent to buy a lottery. Under standard assumptions on risk aversion only the richest prefer to evade.

We then characterize the game among local authorities and found that if communities are identical the equilibrium must be symmetric. On the contrary, when communities differ in size, smaller communities have strong incentives to lower their tax assuming the cost of reducing revenue from residents but attracting agents from neighboring communities. In equilibrium we prove that smaller communities set lower taxes.

In this framework, when communities differ in income distribution there are two opposing effects. Decreasing taxes may attract rich neighbors, increasing the tax base (a stealing effect). But given the nature of the decision whether to evade or not poor agents do not tend to take their chances and therefore increasing taxes even at the cost of reducing the tax base may increase total revenue (a captive effect). We show that the overall effect is ambiguous. Alternatively we could think of a model were the chance of getting caught is irrelevant, or is perceived to be irrelevant. In that case the existence of a fine plays no role in the cheating decisions of agents. We then present an alternative model were the key ingredient in the agents' cheating decision is the time cost of paying taxes in a different community. Since its natural to assume that the opportunity cost of evading is increasing with income level, in this case only the poorest people will cheat.

The two modeling alternatives presented predict different evasion patterns. If the right model is the original one and the evaders are the richest people we should observe a higher proportion of expensive cars registered in the community receiving an inflow of evaders. Formally, the distribution of car values registered in the low tax community should first-order stochastic dominate the distribution in the high tax community. If the right model is the second one presented and poorer agents are the cheaters we should observe the opposite. Using data on automobile registrations on several communities in Uruguay, we apply two non-parametric first order dominance tests to the empirical automobile distribution function. After controlling for income differences, the evidence favors the hypothesis that in the Uruguayan Automobile Registration System richer people are the evaders.

In brief this paper presents several contributions to the literature on fiscal federalism. First it presents two modeling alternatives and shows how fiscal federalism may in fact allow for tax evasion. Second this paper endogenized the decision whether to evade or not with local authorities explicitly accounting for this when setting their tax policies. Third the paper characterizes the equilibrium of the tax competition game of identical and different communities. Forth it proposes an original test on the patterns of evasion and applies it for the particular case of the Automobile Registration System in Uruguay.

1 Introduction

Models of fiscal competition among local communities in general assume that agents are mobile, but once they choose their community of residence they obey the law and pay taxes there.[1] Alternatively we could think that moving to a different community is extremely costly and agents may decide not to move but evade taxes. It is often the case that it is easy to verify if an agent paid taxes, but it is harder (or impossible) to check if he paid them in the correct location. Examples of illegal cross-border shopping to avoid taxes in the US include smuggling of alcohol and tobacco across state borders. Several empirical studies point out that illegal cross-shopping of alcohol and tobacco is a relevant factor in understanding sales differentials between US states.[2] Local governments' strategic behavior plus cross border shopping may harm the ability of local communities to raise taxes.

Although the rest of the paper uses auto registration as its example, for some jurisdictions even income taxes could fall under the model presented here. In New York City, for example, many people who consider themselves residents nonetheless pay local income taxes in other jurisdictions rather than New York City.

Consider the Automobile Registration System. Every state in the U.S. (and everywhere) demands that every licensed vehicle displays a license plate in order to circulate. Registration fees differ across communities, and agents may illegally choose to register their car in a nearby community. It is very easy to verify if an automobile has paid the specified tax, but it is extremely difficult to verify if it was done in the appropriate place; confronted with an automobile with an out of state license plate, there is no way to know if it has been in the state for one week or for the last two years.

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 have 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]

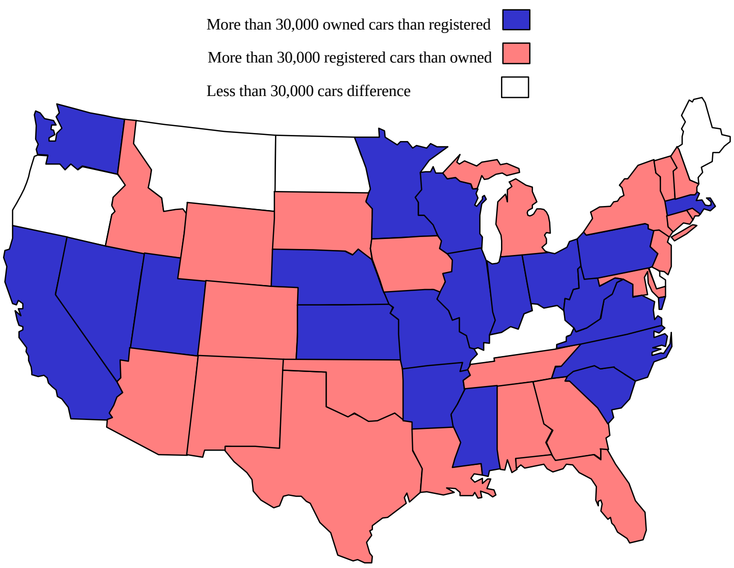
In South America, Uruguayan states are found to behave strategically when setting car registration fees. Montevideo, by far the largest community, has historically set higher fees than other municipalities. In 1995, traffic inspectors controlled the main street access to downtown Montevideo and found 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 residents 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

[1] Tiebout (1956), Wilson (1986), Wildasin (1988), Bucovestky (1991) and Holmes (1995).

[2] Saba et al (1995), Crawford and Tanner (1995) and Beard et al (1997).

[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



of all communities.

In this paper 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 so in their community of residence. Residents in each community are ordered in terms of risk aversion and face di¤erent incentives towards tax evasion, and governments in each jurisdiction take their responses into account when setting tax rates.

In our basic framework we characterize the individual decision of whether to evade taxes under the assumption of risk aversion. We extend existing results in the literature to the case of risk-averse agents. 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 e¤ects of jurisdiction size on the equilibrium tax rates and …nd analogous results in a representative agent framework. In a spatial competition framework, Kanbur and Keen (1993) an 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.

If the focus of the agents' decision are the probability of getting caught an the …ne they eventually have to pay as in our basic framework, only the richest agents evade. Instead, if the key ingredient is the time cost of paying taxes in an neighbor community, only the poorest cheat. If rich people are the cheaters, we should observe a higher proportion of expensive cars registered in small communities. More formally, the small community price distribution of cars should stochastically dominate that of the large community. If poor people are the cheaters, the opposite should happen.

After presenting a forma model implying the previous evasion pattern, we use the implication on the distribution of car values among communities to empirically test both models for the Uruguayan Automobile Registration System. We do so by applying two stochastic dominance test on the empirical cumulative distribution function of car values for different communities in Uruguay. One problem is that small communities are often poorer; therefore, if there is no control for community income level, the results are biased in favor of the "poor people are the cheaters" hypothesis. We have data on cars registered in several communities classified by range of value (from $1 to $1,600, from $1,601 to $2,300, etc.). Controlling for income differences we construct an empirical distribution that allow us to test for stochastic dominance.

The outline of this paper is as follows: we introduce the model in section 2, and the agents' decision problem in section 2.1. We state the game between the local governments and define an equilibrium concept in section 2.2. In section 3 we characterize the properties of pure strategy equilibria for identical and different communities. Section 4 presents an alternative model with a different pattern of tax evasion and tests the implications of both models. Finally we conclude in section 5.

2 The Model

There are two communities, each populated by a continuum of agents who differ in levels of income y. 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 $\int \phi_i(y) d\overline{y} = 1$ 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, therefore agents may decide to pay taxes in a neighbor low tax community and save the tax difference. 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 for simplicity that fines and the monitoring technology are the same across locations.

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.

2.1 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. 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 $u(y - T_1) \gtrless (1 - \pi)u(y - T_2) + \pi u(y - T_2 - F)$. 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 y; such that $y - c(y; T_2) = T_1$; is unique when it exists. Define y_1^* by:

$$y_1^* = \begin{cases} \underline{y} & \text{if } \underline{y} - c(\underline{y}; T_2) \leq T_1 \\ \overline{y} & \text{if } \overline{y} - c(\overline{y}; T_2) \geq T_1 \\ y & \text{if } \underline{y} - c(\underline{y}; T_2) > T_1 \text{ and } \overline{y} - c(\overline{y}; T_2) < T_1: \end{cases} \tag{2.1}$$

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

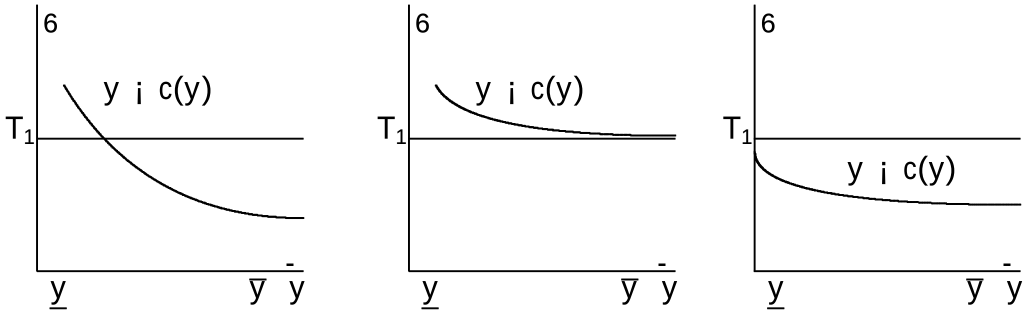
We can have three cases shown in Figure 2.[4] In case B there is no tax evasion, in case C everybody evades, and in case A only the rich do. The individual with income level $y = y^*$ is indifferent. If $y^* = \overline{y}$ there is no tax evasion. According to this Proposition, if in equilibrium there is any tax evasion in a community, it is the rich agents who evade.

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:

[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



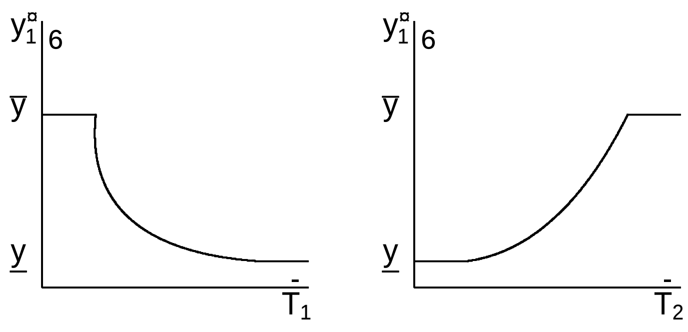
Case A: The Rich Evade   Case B: Nobody Evades   Case C: Everybody Evades

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

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

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.

2.2 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:

$$R_1(T_1;T_2) = \begin{cases} \{N_1 + N_2[1 - \Phi_2(y_2^*(T_1;T_2))]\}T_1 & \text{if } T_1 \leq T_2 \\ N_1\Phi_1(y_1^*(T_1;T_2))T_1 + \pi F N_1[1 - \Phi_1(y_1^*(T_1;T_2))] & \text{if } T_1 \geq T_2; \end{cases} \tag{2.2}$$

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 (2.2).[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 function R_i is 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] 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 $\overline{T} < \underline{y}$.

3 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.

3.1 Size Differences

3.1.1 Identical communities: $N_1 = N_2$

In principle, 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. But this intuitions is not correct as shown in Proposition 3, with equally sized communities there cannot be an asymmetric equilibrium in pure strategies.

Proposition 3 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 $T_1 > T_2$. Lemma 2 tells us that $T_1 - T_2 \le \pi F$ holds in this case, but then $y - T_2 - \pi F \le y - T_1$, 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:

$$(1 - \pi)(y - T_2) + \pi(y - T_2 - F) \le y - T_1:$$

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. ■

[6] Community 1 is richer than community 2 if

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

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

Proposition 4 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.

3.1.2 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., $(N_1 - N_2)(T_1 - T_2) \geq 0$.

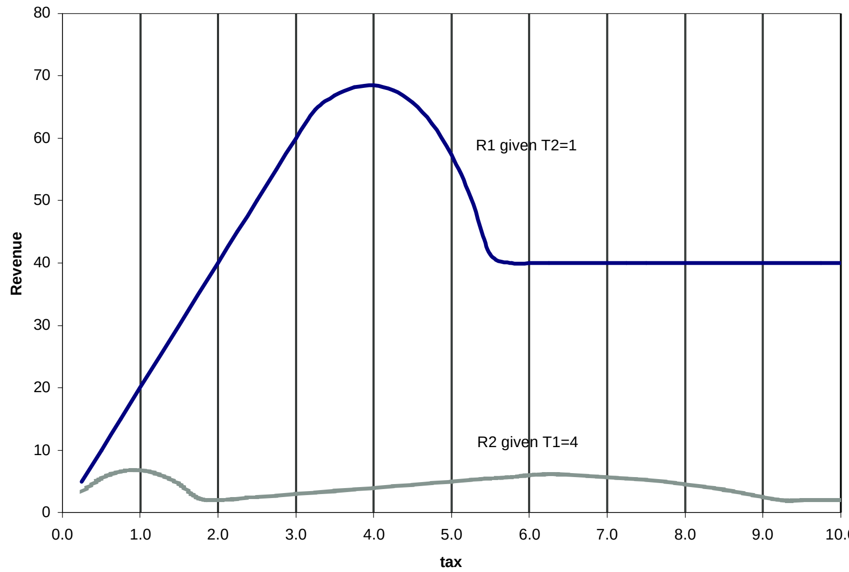
Proof. Let $\theta = N_1/N_2$. Consider the following cases:
Assume without loss of generality that $T_1 < T_2$.
In equilibrium we must have,

$$\begin{aligned} R_1(T_1, T_2) &\geq R_1(T_2, T_2) \\ R_2(T_1, T_2) &\geq R_2(T_1, T_1). \end{aligned} \tag{3.1}$$

Expanding we can express these inequalities as:

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

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



Adding the expressions and manipulating we obtain,

$$(\theta - 1)(T_1 - T_2) \geq (T_2 - T_1 - \pi F)[1 - \Phi(y_2^*(T_2; T_1))]. \tag{3.2}$$

The argument in Lemma 2 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.

3.2 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, 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 $\hat{y}_1$. 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 $\hat{y}_1 = \overline{y_2}$ or $\hat{y}_1 = \underline{y_2}$ (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).

4 An alternative model of Tax Competition

So far we have assumed that local governments can verify if an individual contributes or not, but not if she is paying taxes in her place of residence. If agents decide to cheat they face a probability of getting caught in which case they have to pay a fine F. Proposition 1 shows that in this environment if there is any evasion only the richest agents will decide to evade.

Alternativelly assume that the chance of getting caught is irrelevant, or is perceived to be irrelevant. In that case the existence of a fine plays no role in the cheating decisions of agents. Assume also that every agent has a time cost of paying taxes in a community different than his own. We represent this time cost with a function $\mu(y)$. If richer people are the ones that have higher wages it is natural to assume that $\mu' > 0$:

Proposition 5 *Suppose the time cost $\mu(y)$ satisfies $\mu' > 0$. 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 $y \leq y_i^*$ decides to evade, and those with $y > y_i^*$ decide not to.*

Proof. If an agent in community 1 pays taxes in community 1 his utility level is $u[y - T_1]$. If he decides to cheat and pay taxes in community 2, his utility level is $u[y - T_2 - \mu(y)]$. An agent will not evade taxes if:

$$y - T_1 > y - T_2 - \mu(y)$$

That is to say an agent will not cheat if

$$\mu(y) > T_1 - T_2$$

The left hand side is increasing while the right hand side is constant. Therefore, it must be the case that if there is an agent with income level y^* such that he is indifferent between evading or not, all agents with income level below y^* will strictly prefer to evade and pay taxes in community 2. ■

Proposition 5 is the analogous for the alternative model presented in this section to proposition 1 in section 2.1. Proposition 5 states that if there is any cheating from one community to the other, the evaders are the poorest people while proposition 1 states that whenever there is evasion, the richest people are the cheaters.

Although is not presented in this paper, following a similar reasoning it is possible to prove a result analogous to Theorem 1 were larger communities set on equilibrium higher taxes.

4.1 Empirical Implication

Suppose two communities have the same income distribution. If communities are leviathans under both modelling alternatives small communities have an incentive to set lower taxes and receive some cheaters from the large community. The implication regarding the Automobile Registration System is that smaller communities will register some cars from other jurisdictions.[7]

If the specified model is the original one, the evaders are the richest people. If the model is specified under the alternative, poorer people are the cheaters. If rich people are the cheaters, we should observe a higher proportion of expensive cars registered in the small community. Formally, the distribution of car values registered in the small community should first-order stochastic dominate the distribution in the large community. If poor agents are the cheaters, we should expect the opposite.

Corollary 2 Let $L(\cdot)$ be the distribution function of car values registered in the large community and $S(\cdot)$ the distribution function of a small community. Assume both communities have the same income distribution.

a. If the original model is appropriate S first-order stochastically dominates L:

b. If the alternative model is appropriate L first-order stochastically dominates S:

4.2 Two Test of Stochastic Dominance

Suppose there are two samples taken from two distributions. If a priori it is known that both samples belong to a certain family of distributions $F(\theta_i)$ with unknown parameter θ_i, testing for stochastic dominance is equivalent to estimating θ_i and concluding on the stochastic dominance pattern from there. For instance, in a sample for community a and b, if it is possible to assume that $F_a \sim \exp(\theta_a)$ and $F_b \sim \exp(\theta_b)$, it is easy to see that F_a first order stochastically dominates F_b if and only if $\theta_b > \theta_a$. Therefore, a parametric approach to stochastic dominance testing basically consists on assuming a family of distributions, estimating the necessary parameters from the sample and concluding from there.

We would like to estimate both models for the Uruguayan Automobile Registration System but there is no basis to assign an a priori distribution. Therefore we will use two

[7] Montevideo the country capital city is by far the biggest community and has historically set higher taxes. In 1998, Montevideo signed an agreement with most of the other communities. Under this agreement every community charges the same nominal amount. However, Montevideo is not permitted to finance it in more than three installments while in other communities, car owners can do it up to in six. Moreover Montevideo is allowed to give a 10% discount if the tax is cancelled in one payment while the other can give up to 20%.

non-parametric tests presented in more detail in the appendix. The …rst test was introduced by Anderson (1996) and is a variation over Pearson's goodness of …t test. The second test, was …rst proposed by McFadden (1989) under the assumption of independent distributed samples, and later extended by Klecan, McFadden and McFadden (1991) (KMM onwards) allowing for some statistical dependence of the random variables within an observation period, and across periods.

4.3 The Data

We collected data on cars for seven Uruguayan communities: Montevideo, Maldonado, Salto, Paysandú, Artigas, Rocha and Durazno. For each community we have the number of registered cars in 1999 classi…ed over …fty range values (from $1 to $1,600, from $1,601 to $2,300, etc.). The test is conducted over ten range values, therefore several of the original ranges were added up. The criterion used was that Montevideo's distribution has approximately one tenth of total cars in each range.

4.4 Controlling for Income Di¤erences

Given that in Uruguay smaller communities are poorer, the original series is biased in favor of the hypothesis of poor people cheating. Therefore, there is the need to control for income di¤erences. We generate empirical car distributions from the original distribution, data on income di¤erentials over communities and an assumption on car-income elasticity.

There are no empirical studies on automobile demand for Uruguay but there are several for the United States. Most of the studies have estimated income elasticities greater than 2.0.[8]

Since cars are bought in integer quantities, what do these elasticities really mean? Quoting Hess (1977): "The theoretical treatment of autos as a continuous variable must be reconciled with the observation that they are purchased in integer quantities. This is done by arbitrarily selecting one auto as the standard unit and then calculating the number of units in each other auto in terms of the ratio of the price of that auto to the price of the standard unit. Since these price ratios are continuous a continuously variable number of auto units is purchasable". Basically, all studies use expenditure on cars to estimate car demands.

Let ´ be the estimated income elasticity of demand. A 10% increase in income implies an ´10% increase in the total expenditure in cars. But this may be re‡ected in a better (more expensive) car or in an increase in the number of owned cars. If the number of cars is constant, people must be buying cars that there are ´10% more expensive. In general, people may buy an extra car or they may buy a more expensive one. Therefore, for a given estimated income elasticity, an assumption on consumer behavior is needed.

According to the 1996 Census only 26% of the Uruguayan households own at least one vehicle, and only 3% own more than one. This data is roughly constant among communities.

[8] Nerlove (1957), Suits (1958, 1961), Chow (1960), Dyckman (1966), Hymans (1970) and Juster and Wachtel (1972).

Table 1: Household's Automobile Ownership Structure

proportion of households with:	one vehicule	more than one	no vehicules
Artigas	22.2%	3.5%	74.3%
Durazno	24.0%	3.3%	72.7%
Maldonado	23.4%	2.6%	76.8%
Montevideo	21.1%	2.1%	77.5%
Paysandu	19.9%	2.6%	75.1%
Rocha	20.9%	2.0%	77.1%
Salto	22.9%	2.4%	74.8%
Total	23.3%	3.2%	73.5%

Table 2: Rich evaders implications

	1	2	3	4	5	6	7
	Mon.	Mal.	Sal.	Pay.	Art.	Roc.	Dur.
Montevideo	£	+	+	+	+	+	+

In light of the Uruguayan car ownership structure, we assume that the top 10% of car owners would buy more units while the bottom 90% would buy a better car. It is widely accepted that cars are normal or superior goods, therefore considering income di¤erences with Montevideo (the richest community) for the top three deciles of each community the new series are generated for income elasticities of 1 and 2. The new series should be interpreted as the car distribution of a community if it were as rich as Montevideo.

4.5 Test results

4.5.1 Stochastic Dominance Predictions

According to the 1996 Census, Montevideo is by far the most populated community, ten times larger than Maldonado, second in size, followed by Salto, Paysandú, Artigas, Rocha and …nally Durazno.

Both stochastic dominance tests, Anderson and KMM, produce similar results. They never contradict each other, but in several cases where one of the tests …nds an indeterminancy, the other is able to sign the dominance. In particular, the Klecan, McFadden and McFadden approach gives sharper results.

In tables 2 to 4 a plus (minus) sign implies that Montevideo …rst-order dominates (is dominated by) the community in the vertical axis. A question mark implies that the test is inconclusive. The …rst model presented with the probability of getting caught and the …ne predicts the test results summarized in table 2. The alternative model predicts the opposite signs.

Table 3: Anderson Test Summary

Original Series							Income Elasticity = 1							Income elasticity = 2						
1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
£	+	?	?	?	?	-	£	+	?	?	+	?	?	£	+	+	+	+	?	+

Table 4: KMM Test Summary

Original Series							Income elasticity = 1							Income elasticity = 2						
1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
£	+	-	-	+	?	-	£	+	+	+	+	+	+	£	+	+	+	+	+	+

4.5.2 Results

In the appendix we report the Anderson test for all communities in Uruguay for the generated series under the assumption of income elasticity of 1. Signi…cance is evaluated at the 5% level of con…dence. Using a Pratt test the null of same distribution is rejected in all cases. We also report in the appendix the KMM tests for all communities in Uruguay for the generated series under the assumption of income elasticity of 1, and the critical values for 10% and 5% signi…cance level.

Table 3 summarizes the Anderson …rst order dominance test under di¤erent assumptions for the income elasticity. Table 4 summarizes the KMM at a 5% signi…cance level.

Given the size di¤erences, the most important comparison is the one of Montevideo against the other communities. According to the results of the Anderson test, without taking into account the bias due to income levels, one test favors the rich cheaters hypothesis and one the poor cheaters hypothesis. Controlling for income di¤erences, under the assumption of an elasticity of 1 or 2, the picture de…nitely favors the hypothesis of rich agents cheating.

According to the KMM results without taking into account the bias due to income levels, three tests results fail to favor the rich people cheating hypothesis while two do support it. Controlling for income di¤erences, the results change signi…cantly, and all test favor the rich people are the evaders hypothesis.

Income di¤erences seems to be a relevant variable in explaining di¤erences on car distribution functions over communities. After controlling for income di¤erences, the reported evidence supports the rich agents cheating hypothesis and therefore the modeling alternative of the basic framework and not the alterative model presented.

It still may be possible that time is a relevant variable in deciding whether or not to evade, but if this is the case, it must be that there is a technology available for all agents that will not imply a higher opportunity cost for richer agents.

5 Conclusion

Although most of the paper used auto registration as its example, several other real world cases can be applied like alcohol and tobacco smuggling, on-line trade, or even for some jurisdictions income taxes.

The model developed in this paper 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 studied the agent decision of where to pay taxes under two modeling alternatives. In our basic framework this implies to 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 and end up avoiding high taxes. This feature makes the head tax structure regressive. In our alternative model the time cost of evading is the key ingredient in the decision and therefore only the poorer agents avoid the high taxes making a head tax structure progressive. Presumably, a federal authority in charge of choosing an optimal tax structure would take into account this patterns.

We exploit the difference in the evasion pattern to evaluate which of this two extremes is more close to the Automobile Registration System in Uruguay. Using two stochastic dominance tests to evaluate both models, the evidence presented in this paper seems to be in line with the first one presented were richer people are the evaders.

In brief this paper presents several contributions to the literature on fiscal federalism. First, it presents two modeling alternatives and shows how fiscal federalism may in fact allow for tax evasion. Second, this paper endogenized the decision whether to evade or not with local authorities explicitly accounting for this when setting tax policies. Third, the paper characterizes the equilibrium of the tax competition game of identical and different communities. Finally, it proposes an original test on the patterns of evasion and applies it for the particular case of the Automobile Registration System in Uruguay.

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7 Appendix

7.1 Omitted Proofs

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 $y_1^*(T_1; T_2) \in \left(\underline{y}; \overline{y}\right)$, 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. ■

Proposition 6 The cut-off level y_1^* defined in equation (2.1) is continuous in $(T_1; T_2)$.

Proof. 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 $U(y^*(T_1, T_2, F), T_1, T_2, F) = 0$ is continuous in the set of policies (T_1, T_2). ■

Lemma 2 If $N_1 \neq N_2$, then in equilibrium, $|T_1 - T_2| > \pi F$.

Proof. Suppose there is an equilibrium (T_1, T_2) where $T_1 - T_2 \leq \pi F$. Without loss of generality suppose $T_1 > T_2$. Then $T_1 - T_2 \leq \pi F$ implies that $y - T_2 - \pi F \leq y - T_1$ for any y in community 1. Rewriting we have that $(1 - \pi)(y - T_2) + \pi(y - T_2 - \pi F) = y - T_2 - \pi F \leq y - T_1$. That is, the expected payoff to evading taxes is less than the payoff to paying taxes at home, and no one would chose to evade, since risk aversion implies: $u(y - T_1) \geq (1 - \pi)u(y - T_2) + \pi u(y - T_2 - \pi F)$. Therefore, it would pay Jurisdiction 1 to raise its tax rate T_1, and therefore (T_1, T_2) could not be an equilibrium. ■

7.2 Stochastic Dominance Test

7.2.1 Anderson Test

Anderson´s (1996) test is a variation over Pearson's goodness of fit test. Take any random variable Y and partition its range over k mutually exclusive an exhaustive categories. Let x_i be the number of observations on Y falling in the ith category. x_i is distributed multinomialy with probabilities p_i, $i = 1, \ldots, k$, such that

$$\sum_{i=1} x_i = n; \qquad \sum_{i=1} p_i = 1$$

Using a multivariate central limit theorem the $k \times 1$ dimensioned empirical frequency vector x is asymptotically distributed $N(\mu, \Omega)$ where

$$n^{-1}\mu = \begin{bmatrix} p_1 \\ p_2 \\ \cdot \\ \cdot \\ p_k \end{bmatrix} \qquad n^{-1}\Omega = \begin{bmatrix} p_1(1-p_1) & -p_1p_2 & \cdots & -p_1p_k \\ -p_2p_1 & p_2(1-p_2) & \cdots & -p_2p_k \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ -p_kp_1 & -p_kp_2 & \cdots & p_k(1-p_k) \end{bmatrix}$$

Let x^A and x^B be the empirical frequency vectors based upon samples of size n^A and n^B drawn respectively from populations A and B. Under a null of common population distribution and the assumption of independence of the two samples, it can be shown that:

$$v = \frac{x^A}{n^A} - \frac{x^B}{n^B} \text{ is asymptotically distributed as } N(0; m\Omega)$$

where $m = \frac{n^{-1}(n^A+n^B)}{n^A n^B}$, Ω^g is the generalized inverse of Ω and $v'(m\Omega)^g v$ is asymptotically distributed as Chi square$(k-1)$.

F_A first order stochastic dominates F_B if and only if $F_A(y) \leq F_B(y)$ for all $y \in Y$ and $F_A(y) \neq F_B(y)$ for some y.

Let,

$$I_f = \begin{bmatrix} 1 & 0 & 0 & \cdots & \cdots & 0 \\ 1 & 1 & 0 & \cdots & \cdots & 0 \\ 1 & 1 & 1 & \cdots & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ 1 & 1 & 1 & \cdots & \cdots & 1 \end{bmatrix}$$

First order stochastic dominance (a discrete analogue) can be tested as

$$Ho: I_f \left(p^A - p^B\right) = 0 \text{ against } Ho: I_f \left(p^A - p^B\right) \leq 0$$

This hypothesis can be examined with $v_f = I_f v$ which has a well-defined asymptotically normal distribution. The hypothesis of dominance of distribution A over B requires that no element of v_f be significantly greater than 0 while at least one element is significantly less.[9] Dividing each element by its standard deviation permits multiple comparison using the studentized maximum modulus distribution.

7.2.2 Klecan, McFadden and McFadden Test

This method was first proposed by McFadden (1989) under the assumption of independent distributed samples, and later extended by Klecan, McFadden and McFadden (1991) (KMM onwards) allowing for some statistical dependence of the random variables within an observation period, and across periods.

Suppose X and Y are random variables with cumulative distributions F and G. The null hypothesis is that G first order stochastically dominates F i.e. $F(w) \geq G(w)$ for all w. The probability of rejecting the null when it is true is greatest in the limiting case of $F \equiv G$. KMM follow statistical convention defining the significance level of a test of a compound null hypothesis to be the supremum of the rejection probabilities for all cases satisfying the null.

[9] Note that the test is symmetric in the sense that dominance of B over A requires no elements of v_f significantly smaller than zero while at least one element significantly higher.

Suppose there is a random sample $(x_1, \cdots, x_n)$ and $(y_1, \cdots, y_n)$, an empirical test of H_0 : $F(w) \geq G(w)$ for all w is

$$D_n^* = \max_w D_n(w) \text{ with } D_n(w) \equiv \sqrt{n}\,[G_n(w) - F_n(w)]$$

Let $z = (z_1, \cdots, z_{2n})$ be the ordered pooled observations, and $d_i = \begin{cases} 1 & \text{if } z_i \text{ is from the } Y \text{ sample} \\ -1 & \text{if } z_i \text{ is from the } X \text{ sample} \end{cases}$. Let $H_{2n}(z)$ denote the empirical distribution from z.

Define $D_{ni} = \frac{1}{\sqrt{n}} \sum_{j=1}^{i} d_j$ and let $i = 2nH_{2n}(w)$. Then,

$$D_n(w) = \frac{1}{\sqrt{n}} \sum_{j=1}^{2n} d_j 1_{[z_j < w]} \equiv D_{ni}$$

therefore

$$D_n^* = \max_{1 \leq i \leq 2n} D_{ni}$$

This statistic is the Smirnov statistic (Durbin, 1973) where, if X and Y are independent, under the null hypothesis it has an exact distribution. Without the independence assumption D_n^* does not posses a tractable finite sample distribution, nor an asymptotic distribution. However Klecan, McFadden and McFadden suggest a simple computational method for calculating significance levels. In the least favorable case of identical distributions, so the probability of rejecting the null is maximum, every permutation of $d = (d_1, \cdots, d_n)$ is equally likely for any given z. Therefore d and z are statistically independent and the probability $Q_n(d \mid z)$, that D_n^* exceeds level $s > 0$, given H_{2n}, equals the proportion of the permutations of d yielding a value of the statistic exceeding s.

The significance level associated with D_n^*, conditioned on z, equals $Q_n(D_n^* \mid z)$ and can be calculated by Monte Carlo methods. First calculate $D_n^*(d', z)$ for a sample of permutations d' of d, and then find the frequency with which these simulated values exceed D_n^*.

7.2.3 Test Results

To have a clear pattern of dominance in the Anderson test all coefficient must have the same sign or zeros.

In the Klecan, McFadden and McFadden (KMM) tests acceptance at 5% are boxed.

Tests are presented for pairs of communities but in order to save space we present the detailed results just for the generated series under the income elasticity assumption of 1.[10]

[10] All others are available from the author upon request.

7.3 Anderson Test

Mont. Salto		Mont. Artigas		Mont. Pays.	
coef.	s. e.	coef.	s. e.	coef.	s. e.
¡ 0:055	0:0022	0:100	0:0034	¡ 0:120	0:0022
0:100	0:0032	0:141	0:0049	0:036	0:0030
0:227	0:0035	0:268	0:0055	0:008	0:0034
0:188	0:0036	0:263	0:0057	0:054	0:0035
0:210	0:0036	0:348	0:0056	0:138	0:0035
0:307	0:0035	0:414	0:0054	0:136	0:0033
0:271	0:0033	0:482	0:0051	0:206	0:0031
0:268	0:0030	0:458	0:0047	0:206	0:0029
0:325	0:0028	0:515	0:0042	0:204	0:0026
0	0	0	0	0	0

Mont. Rocha		Mont. Durazno		Mont. Mald.	
coef.	s. e.	coef.	s. e.	coef.	s. e.
¡ 0:012	0:0026	¡ 0:038	0:0029	0:067	0:0013
0:144	0:0037	0:118	0:0042	0:162	0:0020
0:142	0:0042	0:245	0:0047	0:220	0:0022
0:134	0:0043	0:212	0:0049	0:247	0:0023
0:219	0:0043	0:196	0:0048	0:229	0:0023
0:219	0:0041	0:206	0:0046	0:326	0:0022
0:191	0:0038	0:276	0:0043	0:266	0:0021
0:151	0:0035	0:251	0:0040	0:222	0:0020
0:207	0:0032	0:307	0:0036	0:199	0:0018
0	0	0	0	0	0

7.4 KMM Test

	Mont. Salto		Mont. Artigas		Mont. Pays.	
	1 Â 2?	2Â 1?	1 Â 2?	2Â 1?	1 Â 2?	2Â 1?
Observation	36	9	55	4	24	8
10% Critical level	12	12	14	14	10	11
5% Critical level	15	15	15	17	11	13
Signi…cance level	.00	.24	.00	.76	.00	.40

	Mont. Rocha		Mont. Durazno		Mont. Mald.	
	1 Â 2?	2Â 1?	1 Â 2?	2Â 1?	1 Â 2?	2Â 1?
Observation	28	6	33	8	33	0
10% Critical level	11	10	10	12	11	14
5% Critical level	13	12	12	13	13	15
Signi…cance level	.00	.44	.00	.40	.00	.96