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# COMMUNITY TAX EVASION MODELS: A STOCHASTIC DOMINANCE TEST

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In a multi community environment local authorities compete for tax base. When monitoring is imperfect, agents may decide not to pay in their community (evasion), and save the tax difference. The agent decision on where to pay taxes is based on the probability of getting caught, the fine he eventually will have to pay and the time cost of paying in a neighbor community. First, we prove that if the focus of the agents' decision is the probability of getting caught and the fine, only the richest people evade. If instead, the key ingredient is the time cost of evading, only the poorest cheat. Second, we test the evasion pattern on the Automobile Registration System in Uruguay using two stochastic dominance tests. The evidence favors in this case the hypothesis that richer people are the evaders.

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*Key words*: tax evasion, stochastic dominance

## I. 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

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[1] For instance see Tiebout (1956), Bucovestky (1991) and Holmes (1995).

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 (for instance see Saba et al. 1995). Local governments' strategic behavior plus cross border shopping may harm the ability of local communities to raise taxes.

Consider the Automobile Registration System. Every state in the U.S. (and elsewhere) demands that every licensed vehicle display 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.[2] It is very easy to verify if an automobile has paid the appropriate 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.

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.

We present the decision problem of an agent living in a high tax community. His decision whether to evade or not will depend on the probability of getting caught, the fine he eventually will have to pay and the time cost of evading. We consider two extreme cases of this model. In the first, the predominant feature is the chance of getting caught and fined and in the second it is the time cost. The key difference is that the first case implies that richer people will evade while the second case implies that poorer agents will.

Gandelman and Hernández-Murrillo (2004) prove in an environment with a positive probability of getting caught and lump sum taxes and fines that only the richest decide to evade and that larger communities have higher taxes. In this paper we extend the evasion result for proportional fiscal policies. The evasion pattern follows from the fact that some fraction of a high tax community will cheat and pay taxes in the low tax community. The benefit from decreasing the tax rate is a larger tax base due to the inflow of cheaters from the other community that decide to pay in the local community. The cost is the decrease in revenue on local agents. Therefore, considering local authorities as Leviathans only interested in raising taxes, smaller communities are more likely to set lower taxes.

[2] Gandelman and Hernandez-Murillo (2004) report tax differentials between some US states and in South America for Uruguayan communities.

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 proving which agents evade in each case 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 tests 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 allows us to test for stochastic dominance.

In brief this note presents three contributions to the literature on fiscal federalism. First, it presents an agent evasion decision problem, focuses on two extreme alternatives and shows how fiscal federalism may in fact allow for tax evasion. Second, it proposes an original test on the patterns of evasion and, third, it applies it for the particular case of the Automobile Registration System in Uruguay.

Section II introduces the agent decision problem, and proves which agent may choose to evade. Section III presents Anderson's (1996) and Klecan, McFadden and McFadden's (1991) non-parametric tests of stochastic dominance. Section IV discusses the data. Finally, Section V presents the results and Section VI concludes.

## II. The decision to evade taxes

Consider a world where there are two communities, each populated by a continuum of agents who differ in level of initial endowment of income $y$ measured in units of the private consumption good. Income distribution in each community is defined on the reals and is characterized by a density function $\phi_i(y) = N_i \psi_i(y)$, where $\int \psi_i(y) dy = 1$, i.e., communities may differ in two dimensions: income distribution $\psi_i$ and size $N_i$.

Local governments set proportional taxes ($t_i$) to finance the local public good. All agents are supposed to contribute in their community of residence. Even though agents may choose to declare residence in the neighboring community and pay taxes there, agents are actually immobile and enjoy the local public good provided in their location of origin.

Local governments can verify if an individual contributes or not, but not if he is paying taxes in his place of residence. If agents decide to cheat they face a probability of getting caught (represented by the level of monitoring, $\pi$) in which case they have to pay a fine $f$ (proportional). 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 $\theta(y)$. If richer people are the ones that have higher wages it is natural to assume that $\theta \geq 0$, $\theta'' \geq 0$ and $\lim_{y \to 0} \theta(y) = 0$.

Therefore the utility function of an agent in the high tax community 1 is: if he pays taxes in community 1 (no evasion), $u[y(1-t_1)]$; if he pays taxes in community 2 (evasion), $(1-\pi)u[y(1-t_2)-\theta(y)]+\pi u[y(1-t_2-f)-\theta(y)]$.

**A. Case I: Fines but no time cost**

Consider now that the time cost of cheating is very low or that agents do not properly perceive it in their utility function. If $t_1 > t_2 + f$ every agent in community 1 will strictly prefer to cheat, and the revenue of community 1 will be zero. This is not an interesting case since in equilibrium it will never happen.

Although Arrow (1965) and Pratt (1964) hypothesized on theoretical grounds that relative risk aversion should be increasing with wealth, there is no consensus in the empirical literature. Friend and Blume (1975) obtained mixed results indicative of either increasing relative risk aversion (IRRA) or constant relative risk aversion (CRRA). Cohn et al. (1975) found decreasing relative risk aversion (DRRA). Morin and Suarez (1983) found that attitude towards risk varies among social groups: the least wealthy exhibiting IRRA and the most wealthy exhibiting DRRA. Bellanti and Saba (1986) replicated the Morin and Suarez work and found DRRA, and Levy (1994) found evidence of DRRA in an experimental study.

In the empirical section of this paper we will focus on automobile registration in Uruguay were less than a third of the population owns at least one car. Considering this and the empirical evidence presented in the last paragraph we will assume that agents have non-increasing relative risk aversion (CRRA or DRRA).

**Proposition 1.** *Suppose $\theta(y)=0$, $t_2 < t_1 < t_2 + f$ and agents with non-increasing relative risk aversion. If there is any evasion in community 1, rich people are the evaders.*

**Proof.** An agent will not evade taxes if $u[y(1-t_1)] \geq (1-\pi)u[y(1-t_2)]+\pi u[y(1-t_2-f)]$. This happens if and only if $c(y,t_2) \leq y(1-t_1)$, where $c(y,t_2)$ is the certainty equivalence of evading taxes in community 2 defined as $u[c(y,t_2)] = (1-\pi)u[y(1-t_2)] + \pi u[y(1-t_2-f)]$. Therefore an agent in community 1 will not cheat if $c(y,t_2)/y < (1-t_1)$. Non-increasing relative risk aversion implies that the left hand side is non-decreasing in $y$ implying that if there is any $y^*$ such that the previous equation is satisfied with equality, all agents with income level above $y^*$ will be indifferent or strictly prefer to evade and pay taxes in community 2. If there is an agent with income level $y^{**}$ such that the previous equation is satisfied with strict inequality, all agents with income level above $y^{**}$ will also strictly prefer to evade and pay taxes in community 2.

**B. Case II: Time cost but no fine**

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. This time cost is represented by $\theta(y)$. If richer people are the ones that have higher wages it is natural to assume that $\theta' \geq 0$, $\theta'' \geq 0$ and $\lim_{y\to 0} \theta(y) = 0$.

**Proposition 2.** *Suppose $\pi = 0$ and/or $f = 0$ and the time cost $\theta(y)$ satisfies $\theta' \geq 0$, $\theta'' \geq 0$ and $\lim_{y\to 0} \theta(y) = 0$. If there is any evasion in community 1, poor people are the evaders.*

**Proof.** If an agent in community 1 pays taxes in community 1 his utility level is $u[y(1-t_1)]$. If he decides to cheat and pay taxes in community 2, his utility level is $u[y(1-t_2)-\theta(y)]$. An agent will not evade taxes if $y(1-t_1) \geq y(1-t_2) - \theta(y)$. That is to say an agent will not cheat if $\theta(y) \geq (t_1 - t_2)y$. The left hand side is non-decreasing at a non-decreasing rate while the right hand side is increasing at a constant rate. Therefore, it must be 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 be indifferent or strictly prefer to evade and pay taxes in community 2. If there is an agent with income level $y^{**}$ such that he prefers to evade taxes, all agents with income level below $y^{**}$ will also strictly prefer to evade and pay taxes in community 2.

**C. Empirical implication**

In the literature on tax competition, the advantages of small regions are characterized by Bucovetsky (1991) and Wilson (1991), who analyze the effects of jurisdiction size on the equilibrium tax rates in a representative agent environment. In a spatial competition framework Kanbur and Keen (1993) also found that smaller regions set lower tax rates.

Suppose two communities have the same income distribution. If communities are Leviathans, small communities have an incentive to set lower taxes and receive some cheaters from the large community because they have a smaller base on which they loose and a larger pool they can attract. The implication regarding the Automobile Registration System is that smaller communities will register some cars from other jurisdictions. Gandelman and Hernández-Murillo (2004) characterize the Nash equilibrium of two revenue maximizing local governments and prove that larger communities set higher taxes. On empirical grounds Gandelman (2000) provides supporting empirical evidence of higher taxes for larger communities for the Uruguayan Automobile Registration System.

If the true model is more similar to Case I, the evaders are the richest people. If the true model is more similar to the alternative Case II, poorer people are the cheaters. If rich people are the cheaters, we should expect to 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 3.** *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 Case I is appropriate, S first-order stochastically dominates L.*

*b. If Case II is appropriate, L first-order stochastically dominates S.*

## III. Two tests 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 $F(\lambda_i)$ with unknown parameter $\lambda_i$, testing for stochastic dominance is equivalent to estimating $\lambda_i$ 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 $F_a \sim \exp(\lambda_a)$ and $F_b \sim \exp(\lambda_0)$, it is easy to see that $F_a$ first order stochastically dominates $F_b$ if and only if $\lambda_b > \lambda_a$. 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 on a priori distribution. Therefore we will use two non-parametric tests.

**A. 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 and exhaustive categories. Let $x_i$ be the number of observations on *Y* falling in the *i* th category. $x_i$ is distributed multinomially with probabilities $p_i$, $I = 1, \ldots, k$, such that

$$\sum_{i=1}^{k} x_i = n, \sum_{i=1}^{k} p_i = 1.$$

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

$$n^{-1}\mu = \begin{bmatrix} p_1 \\ p_2 \\ \cdot \\ \cdot \\ p_k \end{bmatrix}, \tag{1}$$

$$n^{-1}\Omega = \begin{bmatrix} p_1(1-p_1) & -p_1 p_2 & \cdots & -p_1 p_k \\ -p_2 p_1 & p_2(1-p_2) & \cdots & -p_2 p_k \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ -p_k p_1 & -p_k p_2 & \cdots & p_k(1-p_k) \end{bmatrix}. \tag{2}$$

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 $v = \frac{x^A}{n^A} - \frac{x^B}{n^B}$ is asymptotically distributed as $N(0, m\Omega)$, where $m = \frac{n^{-1}(n^A + n^B)}{n^A n^B}$, $\Omega^g$ is the generalized inverse of $\Omega$ 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

$$I_f = \begin{bmatrix} 1 & 0 & 0 & \cdot & \cdot & 0 \\ 1 & 1 & 0 & \cdot & \cdot & 0 \\ 1 & 1 & 1 & \cdot & \cdot & 0 \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ 1 & 1 & 1 & \cdot & \cdot & 1 \end{bmatrix}. \tag{3}$$

First order stochastic dominance (a discrete analogue) can be tested as: $Ho: I_f\left(p^A - p^B\right) = 0$ against $H_1: I_f\left(p^A - p^B\right) \leq 0$.

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.[3] Dividing each element by its standard deviation permits multiple comparison using the studentized maximum modulus distribution.

### B. 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) (henceforth KMM) allowing for some statistical dependence of the random variables within an observation period, and across periods.[4]

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.

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[3] 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.

[4] Recently, Linton, Maasoumi and Whang (2002) proposed a procedure for estimating critical values for an extension of KMM that allows the observations to be generally serially dependent and accommodates general dependence among the variables to be ranked. Their procedure is based on subsampling bootstraps. Given that our data set is small it is problematic to implement.

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

$d_i = \begin{cases} 1 \text{ if } z_i \text{ from } Y \text{ sample} \\ -1 \text{ if } z_i \text{ from X sample} \end{cases}$. Let $H_{2n}(z)$ denote the empirical distribution from $z$.

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

Then, $D_n(w) = \dfrac{1}{\sqrt{n}} \sum_{j=1}^{2n} d_j 1[z_j < w] \equiv D_{ni}$, 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 possess 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 $D_n^*(d' \mid z)$ for a sample of permutations $d'$ of $d$, and then find the frequency with which these simulated values exceed $D_n^*$. $D_n^*$ exceeds level $s > 0$, given $H_{2n}$, equals the proposition of the permutations of $d$ yielding a value of the statistic exceeding $s$.

## IV. The Uruguayan automobile registration system

Uruguay is divided into 19 autonomous local governments. Montevideo, the capital city, is by far the biggest community. "Unfair Competition" between local governments has always been a political issue. Montevideo has historically set higher automobile taxes than the other municipalities. In 1995, traffic inspectors controlled the main street access to downtown Montevideo and found that about 40% of the automobiles were from other communities. Maldonado seems to receive a large amount of these cheaters. In 1985, the car per capita ratios in Montevideo and Maldonado were 0.115 and 0.164 respectively. Over the following ten years Uruguay opened its economy, which resulted in an increase in the amount of cars.

By 1996, the car per capita ratio in Montevideo had increased to 0.140 while in Maldonado it increased to 0.312.

In 1998, Montevideo was finally able to come to an agreement with most of the other communities. Under this agreement every community charges the same nominal amount. However, this same agreement does not permit Montevideo to finance it in more than three installments while in other communities, car owners can do it in up to six. Montevideo is also allowed to give a 10% discount if the tax is cancelled in one payment, while the others can give up to 20%. The empirical part of this paper deals with communities that signed this agreement.

This paper focuses on tax evasion, which depends on the time cost of evading, the probability of getting caught and the fines the agents eventually have to pay. On theoretical grounds, it is possible to think of other hypothesis to explain the Uruguayan car ownership pattern that do not involve cheating. The most basic one is to assume that agents have different preferences over cars and other goods. Second and more interesting, if the public transportation system is worse in one community, agents in this community have a higher need to own their means of transportation. Similarly, big cities tend to have a shortage of parking facilities; this makes it more costly to own a car. Using this argument, one could - in principle - think that the reasons why there are more cars per capita in Maldonado than in Montevideo are better public transportation or worse parking facilities in Montevideo than in Maldonado. The fact that this is not true for other communities, like Salto and Artigas, makes the argument weaker. But by no means these hypotheses are disproved. To do so, it would be necessary to have access to very specific data for each community that is not available. Finally, in the community competition literature, sometimes it has been assumed that agents have idiosyncratic (ad hoc) transportation costs (Holmes 1995). Under this assumption, people with lower transportation costs will cheat. Again, here we have a data problem; we do not have a good proxy of this transportation cost.

We need to stress that the model presented previously captures two important features of car registration in Uruguay. With respect to fines, they are effectively imposed when a municipality can prove that an agent was evading taxes. Over the last years, there is casual evidence of periodical "community-wars" (Montevideo vs Flores, Florida and Durazno vs Flores, Montevideo vs Canelones, Montevideo vs Maldonado) in which cars with licence plates of certain municipalities are stopped by traffic inspectors and asked to prove their residence. Whenever they are not able to do that, the inspectors may take the driver's licence. The driver then has to go to the municipality to prove his residence or pay a fine. In other cases municipality authorities made public announcements that such policies would be carried out, and although we do not know for sure that such monitoring of licence plates was carried out, in the eyes of drivers the probability of such a monitoring exists and therefore evaders face a subjective probability of getting caught. With respect to the time cost, this is even a more evident real life feature of tax evasion, since you have to drive to the community where you want your car to be registered the first time you do that and in most cases, at least annually, you need to go there to pay the annual taxes. For instance, Maldonado has special discounts on car taxes paid in January. Since it is coincidental with the summer season when they receive lots of tourism from Montevideo, this may be seen as a strategy to lower the time cost of Montevideo residents that pay taxes in Maldonado.

### A. The data

We collected data on cars for seven Uruguayan communities: Montevideo, Maldonado, Salto, Paysandú, Artigas, Rocha and Durazno. Of those communities that agreed to provide data for this paper, Maldonado was the community where it was more difficult to have access to the data. For all communities but Maldonado, we have the number of registered cars in 1999 classified over fifty range values (from $1 to $1,600, from $1,601 to $2,300, etc.). For Maldonado our data is disaggregated just in ten range values, defined in such a way that in Montevideo's distribution there is approximately one tenth of total cars in each category.

Therefore several of the original ranges were added up. The tests presented in this paper are conducted over ten range values for all communities. The information loss due to adding up several ranges is not big since all ranges that were added up belong to our tenth range, i.e. there is no thinner information available for the first nine ranges.[5]

### B. Controlling for income differences

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 differences. We generate empirical car distributions from the original distribution, data on income differentials over communities and an assumption on car-income elasticity.

[5] We also conducted (not reported) the tests for all communities but Maldonado over the fifty ranges and the results do not change significantly.

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.[6] 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”. Basically, all studies use expenditure on cars to estimate car demands.

Let $\eta$ be the estimated income elasticity of demand. A 1% increase in income implies an $\eta$ % increase in the total expenditure in cars. But this may be reflected 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 are $\eta$ % 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 as shown in Table 1.

**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 | 21.1% | 2.1% | 76.8% |
| Maldonado | 30.5% | 4.4% | 65.1% |
| Montevideo | 22.1% | 3.4% | 74.5% |
| Paysandú | 26.6% | 3.6% | 69.8% |
| Rocha | 23.8% | 2.6% | 73.5% |
| Salto | 22.6% | 3.4% | 74.0% |
| Total | 23.3% | 3.2% | 73.5% |

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 differences with Montevideo (the richest community) for the top three

[6] For instance see Nerlove (1957), Suits (1958), and Juster and Wachtel (1972).

decils 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.[7]

## V. Test results

### A. Averages

Before turning to the test, one basic implication of rich people cheating (if communities have the same income levels) is that the cars registered in the communities that receive the cheaters should have a higher average value. Given that small communities are the ones that may receive the cheaters, Montevideo's average should be smaller than that of the other communities. Table 2 reports weighted averages for each community (Maldonado is not reported since we do not know the distribution of the tenth range, cars over $11.100).

**Table 2. Registered cars' average price (in current U.S. dollars)**

| | Mont. | Salto | Artigas | Pays. | Rocha | Durazno |
|---|---|---|---|---|---|---|
| Original Series | 7,147 | 8,275 | 8,782 | 5,940 | 6,181 | 5,977 |
| Elasticity=1 | 7,147 | 12,817 | 16,889 | 8,828 | 8,499 | 9,858 |
| Elasticity=2 | 7,147 | 15,369 | 23,299 | 12,005 | 10,438 | 13,384 |

### B. 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 finally Durazno.[8]

Both stochastic dominance tests, Anderson and KMM, produce similar results.

[7] The results presented in the paper are based on mean generated distributions. The results are qualitatively similar under an alternative range-uniform generated distribution. In this approach, instead of computing the mean value of each range and applying the respective elasticity to it, we apply the elasticity to the extremes of each range. Assuming that cars are distributed uniformly within each range, it is possible to calculate what fraction of cars goes to each range.

[8] In 1996 the population was: Montevideo 1,344,800, Maldonado 127,500, Salto 117,600, Paysandú 111,500, Artigas 75,100 Rocha 70,300 and Durazno 55,700.

They never contradict each other, but in several cases where one of the tests finds an indeterminacy, the other is able to sign the dominance. In particular, the Klecan, McFadden and McFadden approach gives sharper results.

In tables 3 to 5 a plus (minus) sign implies that the community in the horizontal axis first-order dominates (is dominated by) the community in the vertical axis. A question mark implies that the test is inconclusive. If size differentials are such that all tests have clear signs, Case I predicts the test results summarized in Table 3. Case II predicts the opposite signs.

**Table 3. Model 1 implications**

| | | Mon. | Mal. | Sal. | Pay. | Art. | Roc. | Dur. |
|---|---|---|---|---|---|---|---|---|
| 1 | Montevideo | x | + | + | + | + | + | + |
| 2 | Maldonado | | x | + | + | + | + | + |
| 3 | Salto | | | x | + | + | + | + |
| 4 | Paysandu | | | | x | + | + | + |
| 5 | Artigas | | | | | x | + | + |
| 6 | Rocha | | | | | | x | + |
| 7 | Durazno | | | | | | | x |

### C. Anderson test results

In the Appendix we report the Anderson test for Montevideo for the series generated under the assumption of income elasticity of 1. Significance is evaluated at the 5% level of confidence. Using a Pratt test, the null of same distribution is rejected in all cases. Table 4 summarizes the Anderson first order dominance test under different assumptions for the income elasticity.

Without taking into account the bias due to income levels, seven tests favor Case II implication of poor cheaters. These results are biased. Controlling for income differences, no more than three tests favor Case II. Under an income elasticity of 1, five tests favor Case I and finally with an elasticity of 2, eight tests favor the rich people cheating hypothesis (Case I).

Given the size differences, the most important comparison is the one of Montevideo against the other communities. On the original series, one test favors the rich cheaters hypothesis and one the poor cheaters hypothesis. Under the assumption of an elasticity of 1 or 2 the picture definitely favors the hypothesis of rich agents cheating.

**Table 4. 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 |
| 1 | x | + | ? | ? | ? | ? | - | x | + | ? | ? | + | ? | ? | x | + | + | + | + | ? | + |
| 2 | | x | - | - | ? | - | - | | x | ? | ? | ? | ? | ? | | x | ? | ? | ? | ? | ? |
| 3 | | | x | - | + | ? | ? | | | x | - | + | ? | ? | | | x | - | + | ? | ? |
| 4 | | | | x | + | ? | ? | | | | x | + | ? | + | | | | x | + | ? | + |
| 5 | | | | | x | ? | - | | | | | x | ? | - | | | | | x | - | - |
| 6 | | | | | | x | ? | | | | | | x | ? | | | | | | x | ? |
| 7 | | | | | | | x | | | | | | | x | | | | | | | x |

The tests that seem to be failing are Salto-Paysandú and Artigas with Rocha and Durazno, but in these cases the size difference is relatively small. Salto is just 5% larger than Paysandú and Artigas is 7% and 35% larger than Rocha and Durazno respectively.

In all comparisons where the size difference is at least 50%, no test favors Case II implication of poor cheaters. With unitarian income elasticity, four tests favor Case I and with an income elasticity of 2, seven out of eight tests favor Case I.

**D. Klecan, McFadden and McFadden test results**

In the Appendix we report the KMM tests for Montevideo for the series generated under the assumption of income elasticity of 1 and the critical values for 10% and 5% significance level. Table 5 summarizes the KMM first order dominance test under different assumptions for the income elasticity at a 5% significance level.

Without taking into account the bias due to income levels, most of the tests results fail to favor the rich people cheating hypothesis. Considering just the comparison with Montevideo, three tests favor Case II, and two Case I.

Controlling for income differences, the results change significantly. Overall, more tests favor the rich people cheating hypothesis, and when restricted to the cases where size difference are at least 50%, under an income elasticity of 1 nine tests favor Case I and three Case II; under an income elasticity of two, no test favors the poor people are the cheaters hypothesis and ten favor the rich people cheating hypothesis.

**Table 5. 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 |
| 1 | x | + | - | - | + | ? | - | x | + | + | + | + | + | + | x | + | + | + | + | + | + |
| 2 | | x | - | - | - | - | - | | x | ? | - | ? | - | - | | x | ? | - | ? | ? | ? |
| 3 | | | x | ? | + | ? | ? | | | x | - | + | - | ? | | | x | ? | + | ? | + |
| 4 | | | | x | + | + | ? | | | | x | ? | + | + | | | | x | ? | + | + |
| 5 | | | | | x | - | - | | | | | x | ? | - | | | | | x | ? | - |
| 6 | | | | | | x | - | | | | | | x | + | | | | | | x | + |
| 7 | | | | | | | x | | | | | | | x | | | | | | | x |

Again, given the size differences, the most important comparison is the one of Montevideo against the other communities. Even under an income elasticity of 1, all tests favor Case I.

## VI. Conclusions

We model an agent's decision on where to pay taxes and focus on two extreme cases. In Case I, the determinant of the evasion pattern is a fine and a probability of getting caught when evading. In Case II, the time cost of cheating is stressed. According to the implications of Case I, if there is any evasion from one community to the other, richer people are the evaders. On the other hand, Case II implies that if there is any evasion, poorer people should be the evaders.

We tested empirically these two implications for the Automobile Car Registration System in Uruguay. Income differences seems to be a relevant variable in explaining differences in car distribution functions over communities. After controlling for income differences, the reported evidence supports the rich agents cheating hypothesis and therefore supports Case I.

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.

## Appendix: Stochastic dominance test results

To have a clear pattern of dominance in the Anderson test all coefficients must have the same sign or zeros. In the Klecan, McFadden and McFadden (KMM) tests acceptance at 5% have an asterisk. In order to save space, we only present the full tests for Montevideo under the income elasticity assumption of 1.

**Table A.1. Anderson test: Montevideo versus other communities**

| Salto | | Artigas | | Paysandú | | Rocha | | Durazno | | Maldonado | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| coef. | s.e. | coef. | s.e. | coef. | s.e. | coef. | s.e. | coef. | s.e. | coef. | s.e. |
| -0.055 | 0.002 | 0.100 | 0.003 | 0.120 | 0.002 | -0.012 | 0.003 | -0.038 | 0.003 | 0.067 | 0.001 |
| 0.100 | 0.003 | 0.141 | 0.005 | 0.036 | 0.003 | 0.144 | 0.004 | 0.118 | 0.004 | 0.162 | 0.002 |
| 0.227 | 0.004 | 0.268 | 0.006 | 0.008 | 0.003 | 0.142 | 0.004 | 0.245 | 0.005 | 0.220 | 0.002 |
| 0.188 | 0.004 | 0.263 | 0.006 | 0.054 | 0.004 | 0.134 | 0.004 | 0.212 | 0.005 | 0.247 | 0.002 |
| 0.210 | 0.004 | 0.348 | 0.006 | 0.138 | 0.004 | 0.219 | 0.004 | 0.196 | 0.005 | 0.229 | 0.002 |
| 0.307 | 0.004 | 0.414 | 0.005 | 0.136 | 0.003 | 0.219 | 0.004 | 0.206 | 0.005 | 0.326 | 0.002 |
| 0.271 | 0.003 | 0.482 | 0.005 | 0.206 | 0.003 | 0.191 | 0.004 | 0.276 | 0.004 | 0.266 | 0.002 |
| 0.268 | 0.003 | 0.458 | 0.005 | 0.206 | 0.003 | 0.151 | 0.004 | 0.251 | 0.004 | 0.222 | 0.002 |
| 0.325 | 0.003 | 0.515 | 0.004 | 0.204 | 0.003 | 0.207 | 0.003 | 0.307 | 0.004 | 0.199 | 0.002 |
| 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Table A.2. KMM test: Montevideo versus other communities**

| | Salto | | Artigas | | Paysandú | | Rocha | | Durazno | | Maldonado | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1>2? | 2>1? | 1>2? | 2>1? | 1>2? | 2>1? | 1>2? | 2>1? | 1>2? | 2>1? | 1>2? | 2>1? |
| | | * | | * | | * | | * | | * | | * |
| Observation | 36 | 9 | 55 | 4 | 24 | 8 | 28 | 6 | 33 | 8 | 33 | 0 |
| 10% Critical level | 12 | 12 | 14 | 14 | 10 | 11 | 11 | 10 | 10 | 12 | 11 | 14 |
| 5% Critical level | 15 | 15 | 15 | 17 | 11 | 13 | 13 | 12 | 12 | 13 | 13 | 15 |
| Significance level | 0 | 0,24 | 0 | 0,76 | 0 | 0,4 | 0 | 0,44 | 0 | 0,4 | 0 | 0,96 |

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