Tax auditing interdependence among sub-central administrations

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First Draft

ABSTRACT

The tax administration parameters have scarcely been analyzed by the literature as relevant policy-making instruments; however the enforcement strategies are crucial elements of the tax management. In this paper we show that in a federal framework the tax auditing policies could represent additional tools on which regional institutions can interact between them. We develop a horizontal tax competition model with two tax instruments: the tax rate and the tax auditing rate in order to empirically test its findings. For what concern the tax auditing rate, the results are in line with the literature on tax rate competition: the Leviathan administrations compete in a race to the bottom in order to not lose the tax bases. In particular we find that the slope of the administration's reaction function is positive. The empirical analysis starts with a study of the determinants of the tax administration. A suboptimal size of tax administration emerges. Some of the budgetary variables have a good explicative power but don't represent the main effect at work. For this reason we formally introduce the tax competition. Testing for spatial interactions corroborates the horizontal tax competition hypothesis provided by the theoretical model. Controlling for horizontal tax competition the size of tax administration is optimal: the regional administrations are tamed by the mobility based competition.

Keywords: tax administration and auditing, fiscal competition, fiscal federalism

JEL Classification: H71, H77, H83

1. Introduction

The theoretical literature on the taxation policy interactions among governments is vast and extensively analyzed the tax rates interdependencies in federal contexts. Namely it is possible to identify three main research lines. The first analyzes a decentralized framework in which local governments compete in a "race to the bottom" when fixing the tax rates in order to gain or not to lose the tax bases. In the academic debate there are two divergent approaches regarding the "horizontal tax competition" issues (see Wilson, Wildasin, 2004 for a survey): the first designs the policymaker as a benevolent government and stresses that the non-cooperative behaviour will lead to inefficient outcomes (see Zodrow, Mieszkosky, 1986 and Wilson, 1986), while the second models the policymaker as a Leviathan that needs to be tamed and see tax competition as a mean to limit excessive high tax pressure (see Brennan and Buchanan, 1980). Edwards and Keen (1996) synthesise these two opposite views modelling the governments as neither wholly benevolent nor wholly revenues maximizing. Despite the opposite welfare conclusions, these two approaches both agree that tax competition lowers the size of government. There is also a large empirical literature that tests these issues (see among others the original work by Oates, 1985 and Brülhart, Jametti, 2008 for a recent contribution).

The second line of research deals with a federal context in which voters use the tax policy of the neighbouring governments as information to evaluate the performance of the incumbent politician. This process leads to a yardstick competition between local governments which results in an enhanced accountability process (see Besley and Case, 1995). The last research line is based on the idea that decentralisation could increase policy innovation as a result of a process of policy diffusion between local governments (Ashworth et al., 2006, Ligthart, Voget, 2008, Strumpf, 2002). Regarding the presence of tax administration[1] interdependencies among sub-central governments there is a substantial lack of research and the literature focused on the potential mobility of tax bases. In our particular setting, a yardstick competition framework doesn't seem to apply so we maintain this approach[2]. The most relevant contribution in this sense was given by Cremer and Gahvari (2000)[3]. Using a welfare maximizing vision, they examine the implications of tax evasion for fiscal competition and tax harmonization policies in an economic union. Their results are in line with the horizontal tax competition literature: the equilibrium values of the tax and audit rates are less than optimal and tax harmonization alone is not sufficient to avoid the audit rate inefficient outcome[4].

[1] In this paper we refer to administration parameters as to the tax enforcement that basically corresponds to the tax auditing probability.

[2] In fact it is not easy to obtain information regarding the administrative strategies: even if the information is publicly available it could be very costly for a taxpayer to understand it since it requires a technical advisory. This consultancy cost is sustainable just by a minoritarian share of the voting population that do not represent a credible threat for the incumbent's reappointment.

[3] See also among other works Janeba, Peters, 1999, and, Stöwhase, Traxler, 2005.

[4] They suggest that since auditing strategies are not publicly observable it could be pretty difficult to set a binding agreement between sub-central governments in order to harmonize them. In particular the problem

To the best of our knowledge there are not empirical studies that investigate the presence of tax interaction between different regions at an administrative level. This could be due to a lack of availability of data on the auditing policies and to the difficulty to find an adequate measure to represent the "tax enforcement".

The enforcement strategies are crucial elements of the tax management process and they are of particular interest if we refer to federal countries because the auditing policies could represent a further factor on which local authorities can interact in addition to the tax rates.

Spain represents a good framework to investigate. The Spanish sub-central governments, the "Autonomous Communities" (ACs), have the power to administer several taxes since the mid eighties and recently also obtained the legislative power to modify the respective statutory tax rates[5]. In particular we chose to concentrate our empirical analysis on the inheritance and gift tax (IGT). This is the most relevant deregulated tax and in the last years has been getting topical in Spain as in other federal countries. In fact there is an informal evidence that the Spanish decentralization process has induced a race to the bottom in the IGT tax rates (see Durán, Esteller 2006; López Casasnovas, Durán-Sindreu Buxadé, 2008) and that the same process interested also other decentralized countries (see e.g. Conway, Rork, 2004; Brulhart M., Parchet R.., 2010) and may occur in further federations[6]. Indeed in a decentralized framework, as the principle of residence is applied, an individual would find it convenient to move his residence to a different region in order to pay fewer taxes on the wealth he will transmit to his descendents. In this sense the threat of mobility of the tax bases is the source of the tax competition on the IGT. This opens the possibility that the competition among regions was present also before the decentralization of the legislative power but at an administrative level.

The aim of this paper is to shed more light on these concerns developing a horizontal competition model with two tax instruments, the tax rate and the auditing enforcement with the final aim of empirically testing its findings. The results of the theoretical framework are in line with the literature on tax rates competition: the mobility threat tames the Leviathan administrations that compete in a race to the bottom on both the tax instruments in order to not lose the tax bases. We derive the slope of the administration's reaction function obtaining a positive sign. As a first preliminary empirical analysis we study the determinants of the tax administration highlighting that without controlling for the horizontal tax competition, the tax administration size is suboptimal.

is that, for a local jurisdiction, it is practically impossible to observe and verify the enforcement efforts of the other governments.

[5] More precisely, two waves of reforms occurred: after a first reform (1997), the ACs can change statutory tax rates keeping them close to the national ones; after the second one (2002) they have a complete legislative control on the tax rates. Moreover these two reforms introduced formal forums of interaction between the central and the local tax administrations and informal meetings between the ACs (Durán and Esteller 2008, 2009, 2010).

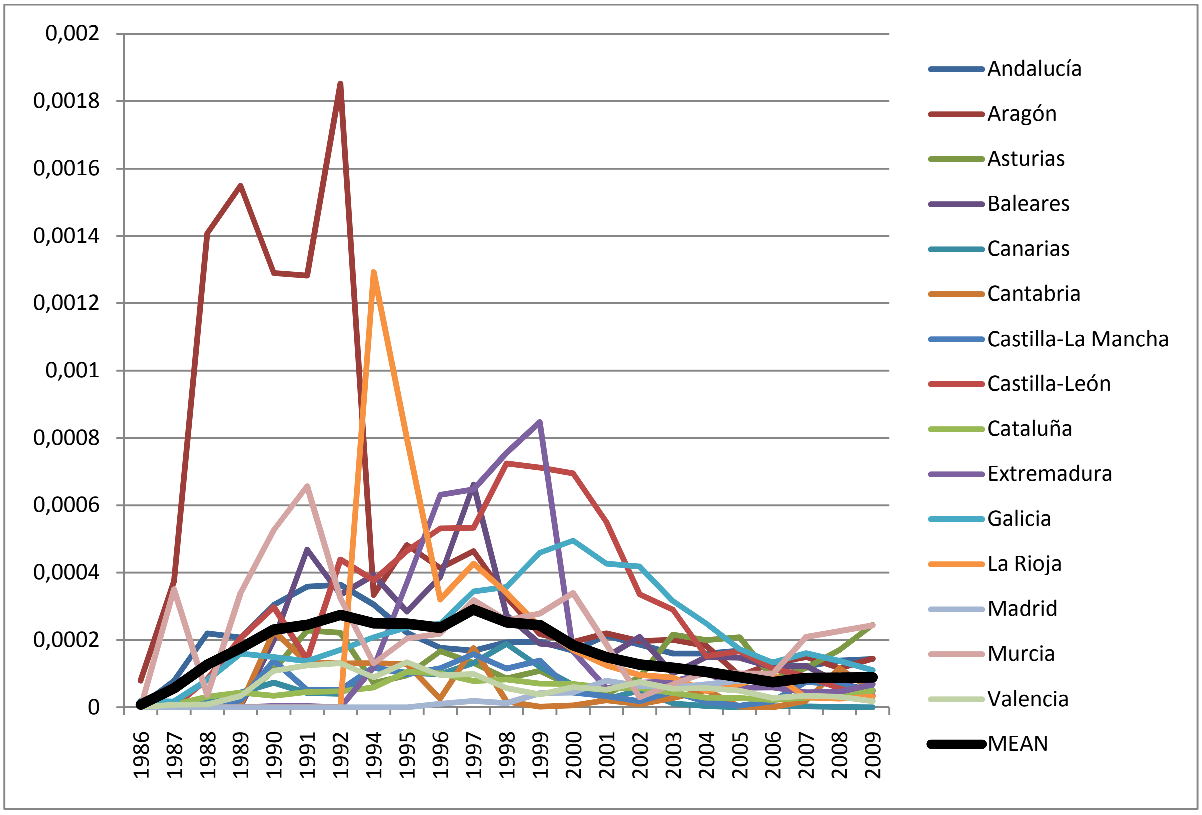
[6] Recently there are signs of interests on these themes also from the European Commission and even if they rise from a different point of view – cross-border discrimination and double taxation – this confirm that the inheritance tax issues are becoming one of growing concern to European citizens (Næss-Schmidt and al., 2011).

Some of the budgetary variables have a good explicative power but it seems that they don't represent the main effect at work when explaining tax administration size. For this reason we formally introduce the tax competition. The theoretical results are tested through a spatial econometric model that confirms the presence of a horizontal tax competition process between the different regions.

The rest of the paper is organized in this way: the next section introduce some trivial empirical evidence on the Spanish case, then the theoretical framework is developed and the empirical analysis performed. The paper ends with some conclusions and further development ideas.

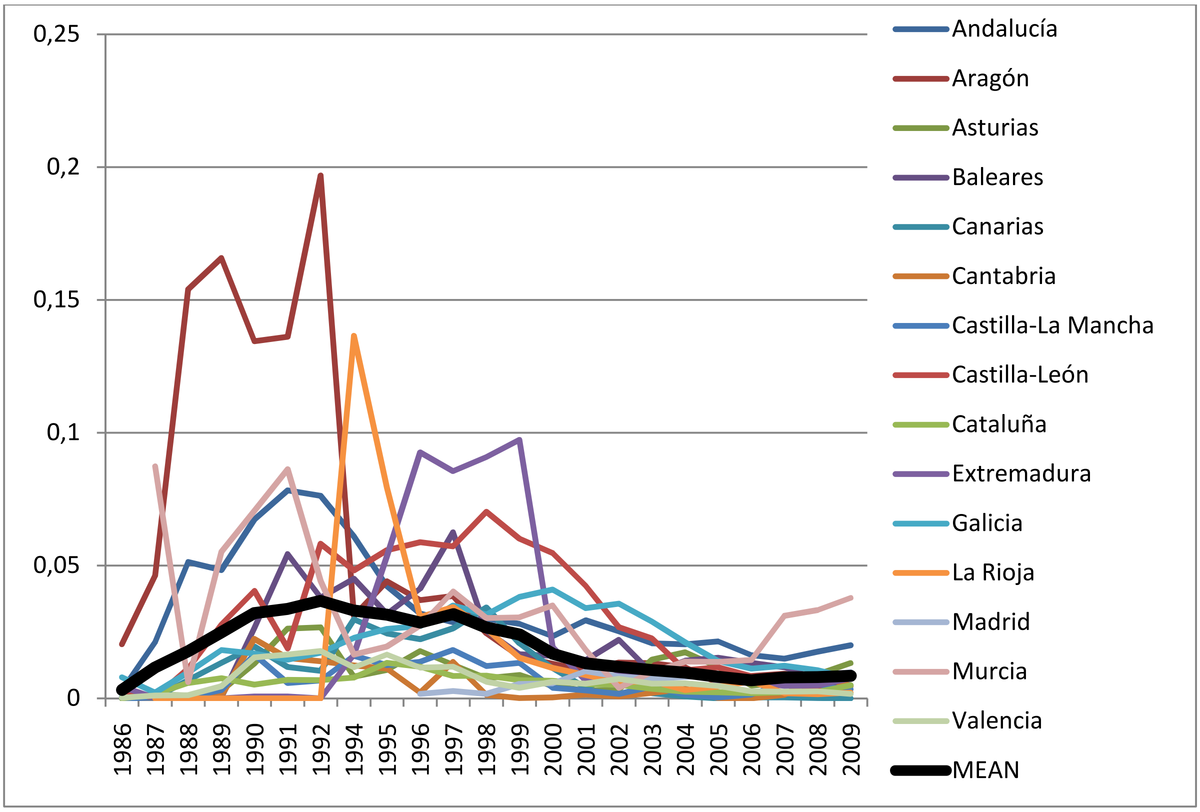
2. Trivial empirical evidence

The Spanish tax administration information is annually released inside the report "Informe sobre la cesión de tributos a las Comunidades Autónomas" published together with the Spanish National Budget "Presupuestos Generales del Estado" this grants the availability of the data for a long period from the mid-eighties up to 2009. The report registers the number of audits performed year by year by each region. We will use this information to define our endogenous variable for the econometric analysis. As a first possible measure of the "tax enforcement" is possible to look at the ratio between the rough number of audits and the regional population (Graph 1). This measure is characterized by a great variance and it is not possible to clearly understand what is happening even if it is clear that in the last year of the period the policies becomes similar across regions and that the average trend is decreasing starting from 1997.



Graph 1: = #Audits /TotPOP

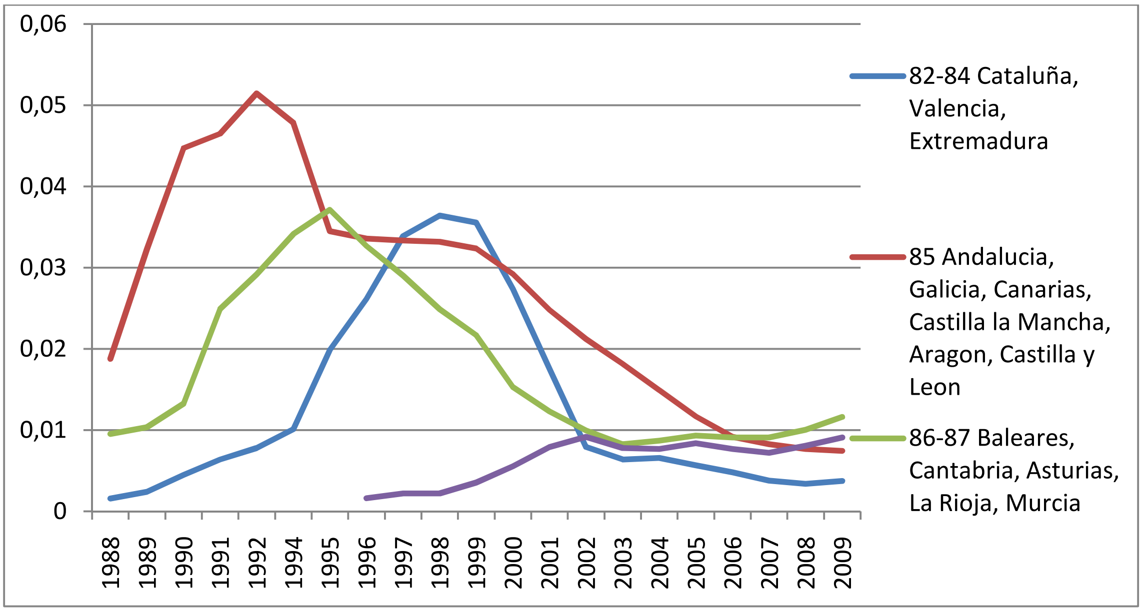
A more standard measure of the "tax enforcement" is the ratio between the total number of audits and the number of tax return. This proxy of the "tax auditing probability" is represented in the Graph 2: the noise is pretty high but it reduces in the last part of the period. An average decreasing trend is confirmed starting from early nineties.



Graph 2: TAR= #Audits/#Tax Returns

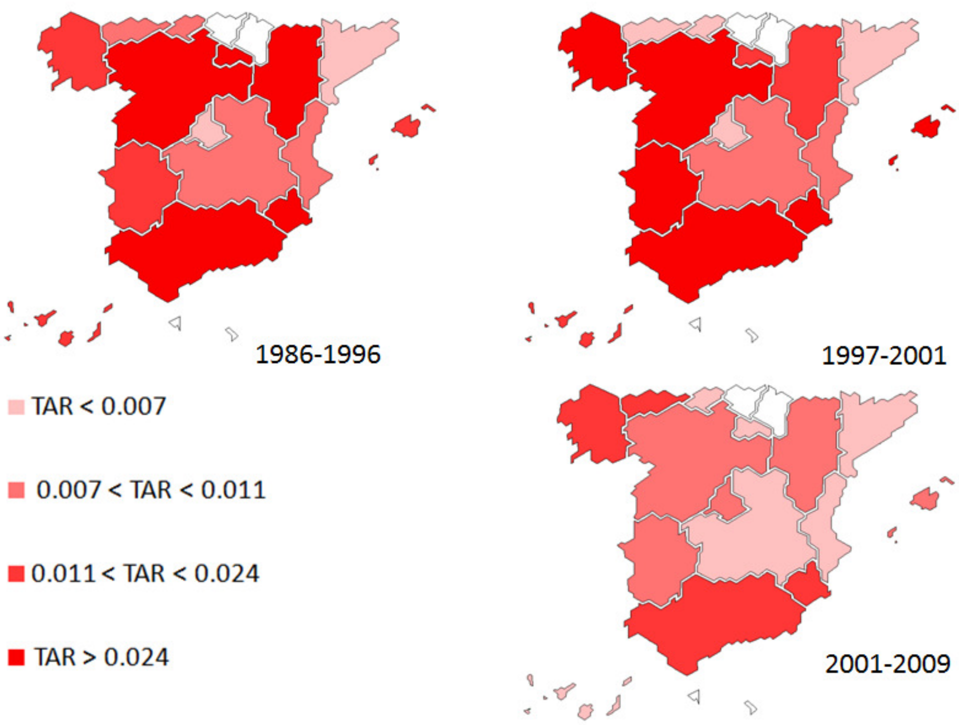
Anyway, as Slemrod, Shaw, and Whiting (2009) suggest this is still a rough measure of the probability of an act of evasion being detected because "to the extent that past years' returns may be audited, the relevant probability is the probability of being caught over a number of years rather than in a single year". For this reason we decided to work with mobile means and in this way we obtain a substantial reduction of the noise. In particular if we look at the mobile means of regional clusters based on the year in which local administrations were instituted (Graph 3) we can identify three main periods that characterize the evolution of the Spanish tax administration. In the first period (1986-1996) we observe an increasing trend in the tax auditing probability: reasonably this is due to some learning sunk costs the regions had to face when started to manage with this new administrative tool. In a second period (1997-2001) a decreasing trend emerges. This could be associated with several things: regions reached a sufficient level of expertise and/or innovated their auditing procedure in order to be more precise; tax competition might also played a role. From

2002 it is possible to see that a convergence process occurred and a long run equilibrium is reached in the regional tax auditing policies.



Graph 3: TAR mobile mean, cluster of regions based on the year in which they received the IGT administration power

In order to have a more clear geographical picture in Graph 4 we present the tax auditing probability mean for every region during this three main periods: as lighter is the colour as lower is the auditing rate. Looking at the last map not only the auditing probability is sensibly lower in most of the regions but it also seems that to a certain measure neighbouring regions have a common pattern of evolution.



Graph 4: TAR, mean for the main 3 sub-periods

3. The theoretical framework: "mobility-based" tax competition in presence of evasion

In this section we present a simple model of tax competition in presence of tax evasion[7]. The framework is modelled as a federal state constituted by two regions $(i = 1,2)$ of equal size in which the total population is normalized to one. At a regional level there are two institutional agents: the government that set the tax rate and the tax administration that controls the auditing policy. Following the most common approach in the literature we assume that both institutions have the same incentives and act as Leviathans[8]: they respectively set tax rates and auditing policies, both maximizing the total tax revenues[9]. Individuals are endowed with an exogenous amount of wealth B that is taxed by the government of the region in which they reside. Taxpayers decide the share of wealth to evade minimizing their tax payment regardless the level of public good provision and can be audited by the regional tax administration. In order to let the solution to be interior tax evasion is assumed to be costly for the individual. Moreover the taxpayers are neutral risk averse in order to avoid any income effects.

The model is developed in four *stages*:

1. Regional governments set tax rates.
2. Regional tax administration set tax auditing policies.
3. Individuals decide in which region set their location in the federation comparing their indirect utility function (based on their current tax burden) in the two regions. This *stage* is solved exploiting the concept of "home attachment" (see Mansoorian, Myers (1993, 1997) for the original framework and Wellisch (2000) for a recent formulation).
4. Taxpayers decide their level of tax evasion.

The solution is provided by backward induction.

[7] The outline is based on the paper by Cremer, Gahvari (2000).

[8] This paper doesn't have any normative intent so the choice between these alternative hypothesis doesn't seem to be crucial in terms of results.

[9] Assuming that both policies are set by the same agent would complicate the model (see Appendix 4 for a formal derivation of the first *stage* under this assumption). In any case the hypothesis of two different institutions that share the same incentives seems to be reasonable in the sense that actually the regional government directly set only the statutory tax rate while it just indirectly controls the auditing policy that is implemented by an administrative office. A possible extension could be to suppose that a bargaining process between the two institutions takes place (Fuest, 2000).

Stage 4: The decision about the level of tax evasion

At this *stage*, given the region he has chosen at *stage* 3 and given the tax policies chosen by the regional institutions at the previous *stages*, the individual decide the share of the tax base he wants to declare. Formally the problem is:

$$\underset{\alpha}{Max}\ U = B \times [1 - t_i \times [\alpha + (1-\alpha) \times \tau \times \beta_i] - g(1-\alpha)] \qquad (1)$$

Where:

$B > 0$ is the exogenous tax base;

$\alpha \in (1, 0)$ is the declared share of the tax base;

$t_i \in (1, 0)$ is the tax rate set by the region $i = 1{,}2$ at the first *stage*;

$\beta_i \in (1, 0)$ is the tax auditing probability set by the region $i = 1{,}2$ at the first *stage*;

$(\tau - 1) > 0$ is the exogenous tax fine per unit of tax evaded;

The function $g(1-\alpha)$ represents the cost of tax evasion $(1-\alpha)$, such that $g'(1-\alpha) > 0$, $g''(1-\alpha) > 0,\ g(0) = 0, g(1) \to +\infty)$. Basically this could be interpreted as a resource/pecuniary cost due to technical advising and/or as a moral cost. In other words, following Cremer and Gahvari (2000), we assume that the unitary cost of tax evasion is a strictly convex function and it only depends on the evaded share of wealth $(1-\alpha)$[10].

It is possible to define the expected tax rate for the region $i = 1{,}2$ as:

$$\theta_i \equiv t_i \times [\alpha + (1-\alpha) \times \tau \times \beta_i] \qquad (2)$$

The First Order Condition leads to:

$$g'(1-\alpha) = t_i \times (1 - \tau \times \beta_i) \qquad (3)$$

This means that the marginal cost of tax evasion (on the left hand side) should be equal to the marginal benefit of tax evasion (on the right hand side); $\tau\beta_i < 1$ should be assumed in order to

[10] Some authors (see among others Slemrod (1994) and Crocker, Slemrod (2005)) assume that the cost of tax evasion should be sustained by the taxpayer just in case of a government's inspection. This means to assume a cost function such as $l(\beta, (1-\alpha)) = \beta \times g(1-\alpha) \leq g(1-\alpha)$. This definition of the cost of tax evasion seems to be closer to the concept of "tax fine" rather than to the concept of "resource cost" (tax consultancy) and/or a "morale-reputation cost" that instead have to be sustained in any state of the world (audited and not audited). As specified above in the text, we assume an exogenous unitary tax fine. See Virmani (1989) for a specification of the resource cost, and Gordon (1989) for a specification of the morale-reputation cost.

avoid the individual to behave honestly[11]. We indicate the optimal level of tax evasion with $(1 - \alpha^*(t_i, \beta_i))$.

Stage 3: The decision about the region in which reside

At this *stage*, some assumption concerning the taxpayers' utility to reside in a region with respect to the other should be introduced.

To model the concept of "home" we assume that taxpayers are indexed by $n \in (1,0)$ and are uniformly distributed between 0 and 1[12].

The preferences of taxpayer n with respect to his location are given by:

$$V(n) = \begin{cases} {U_1}^* + a \times (1-n) & \text{if } n \text{ lives in region 1} \\ {U_2}^* + a \times n & \text{if } n \text{ lives in region 2} \end{cases} \tag{4}$$

Where ${U_i}^* = {U_i}^*(1 - \alpha^*(t_i, \beta_i))$ for *i = 1, 2*, represents the (pecuniary) indirect utility function and where $n \in (1,0)$ measures the non-pecuniary (psychic) benefit the individual derives from living in region 2 and $(1-n)$ the benefit from living in region 1. Thus taxpayers indexed by $n \in \left(0, \frac{1}{2}\right)$ reside in region 1 while the ones identified by $n \in (\frac{1}{2}, 1)$ reside in 2. The parameter $a \in (0, +\infty)$ measures the degree of individual mobility. The interpretation of a is crucial. We assume a to represent the cost to be sustained to move from the home region[13]. The taxpayer's utility to live in his own region increases with the cost of mobility: if the costs are low then the relative importance that the taxpayer assigns to the psychic part of the utility function, with respect to the pecuniary one, is low; the vice versa holds if this cost is high.

Moreover if $a = 0$, the mobility cost is null and the tax bases become perfectly mobile: only the pecuniary part of the utility function matters in the taxpayer's migration decision because it is no more important where a taxpayer lives in order to still obtain utility gains derived from "home attachment". From the institutional point of view this will lead the two regions to compete in a race to the bottom and we would observe a fall in both tax instruments: the symmetric Nash equilibrium will occur in $(t = 0, \beta = 0)$. In the other limit case, if $a \to +\infty$, the mobility costs are extremely high and so the taxpayers are perfectly immobile. This can be interpreted as a centralized economy case in which the tax policies are set by a unique federal planner. These two limit cases are excluded to allow for imperfect mobility of individuals.

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[11] This seems to be a reasonable assumption because even if, for instance, the tax fine $(\tau - 1) > 0$ is equal to 3 that is pretty high level, and so $\tau = 2$, it is necessary a very high (and improbable) auditing probability $\beta_i = 0{,}5$ to obtain $\tau\beta_i = 1$. So $\tau\beta_i = 1$ could be interpreted as a limit case.

[12] See the Appendix 2 for a generalisation of the model that releases this assumption on the population's distribution.

[13] Since mobility could be either real or fictitious, this could be interpreted as the cost of actual mobility or the cost of pretending the move.

Now it is possible to characterize the mobility equilibrium as:

$$U_1{}^* + a \times (1 - n_1) = U_2{}^* + a \times n_1$$
$$U_1{}^* + a \times (1 - n) > U_2{}^* + a \times n \quad \forall n < n_1$$
$$U_1{}^* + a \times (1 - n) < U_2{}^* + a \times n \quad \forall n > n_1 \tag{5}$$

Where $n = n_1$ represents the marginal individual indifferent between living in region 1 and region 2 and, since $\int_0^{n_1} dn = n_1$, it also represents the population in region 1 in the migration equilibrium:

$$n_1 = n_1(t_1, \beta_1, t_2, \beta_2; a) = \frac{1}{2} + \frac{U_1{}^* - U_2{}^*}{2a} = \frac{1}{2} + \frac{B \times [\theta_2 - \theta_1 + g_2 - g_1]}{2a} \tag{6}$$

For sake of simplicity the superscripts on the variables are omitted. The population in region 2 in the migration equilibrium is:

$$n_2 = \int_{n_1}^{1} dn = 1 - n_1 \tag{7}$$

Stage 2: Regional administrations set tax auditing policies

The problem is symmetric: the two administrations compete "a la Cournot" simultaneously setting their tax policies. We develop the problem of the administration 1.

Formally administration 1 faces the following problem given the governments' decision of the first *stage* and anticipating the results of the last two *stages*:

$$\underset{\beta_1}{Max}\ R_1(\beta_1, \beta_2; t_1, t_2, a) = n_1 \times r_1 = \left(\frac{1}{2} + \frac{B \times [\theta_2 - \theta_1 + g_2 - g_1]}{2a}\right) \times [B \times \theta_1 - d(\beta_1)] \tag{8}$$

Where $d(\beta_i)$ represents the tax administration cost such that $d'(\beta_1) > 0, d(\beta_1)'' > 0$ and $r_i \equiv \frac{R_i}{n_i} = [B \times \theta_i - d(\beta_i)\ ]$ is the unitary tax revenue.

The First Order Condition (FOC) of this problem is:

$$\beta_1: \quad r'_{1\beta_1} \times n_1 + n'_{1\beta_1} \times r_1 \equiv R_{1\beta_1}(\beta_1, \beta_2; t_1, t_2, a) = 0 \tag{9a}$$

That could be written as:

$$2n_1 a \times \left[B \times \frac{\partial \theta_1}{\partial \beta_1} - d'(\beta_1)\right] - r_1 \times B \times \left(\frac{\partial \theta_1}{\partial \beta_1} + \frac{\partial g_1}{\partial \beta_1}\right) = 0 \tag{9b}$$

The Second Order Condition (SOC) is:

$$\beta_1: \quad R_{1_{\beta_1\beta_1}}(\beta_1, \beta_2; t_1, t_2, a) < 0 \qquad (10a)$$

That is:

$$2\frac{\partial n_1}{\partial \beta_1} \times \frac{\partial r_1}{\partial \beta_1} + n_1 \times \frac{\partial^2 r_1}{\partial {\beta_1}^2} + r_1 \times \frac{\partial^2 n_1}{\partial {\beta_1}^2} < 0 \qquad (10b)$$

The problem of the region 2 can also be formulated in a similar way.

Stage 1: Regional governments set tax rates

Analogously at the administration's *stage*, the government of region 1 faces the following problem anticipating the results of all the other *stages*:

$$\underset{t_1}{Max}\ R_1(t_1, t_2; \beta_1, \beta_2, a) = n_1 \times r_1 = \left(\frac{1}{2} + \frac{B \times [\theta_2 - \theta_1 + g_2 - g_1]}{2a}\right) \times [B \times \theta_1 - d(\beta_1)] \qquad (11)$$

The FOC of this problem is:

$$t_1: \quad r'_{1_{t_1}} \times n_1 + n'_{1_{t_1}} \times r_1 \equiv R_{1_{t_1}}(t_1, t_2; \beta_1, \beta_2, a) = 0 \qquad (12)$$

The SOC is:

$$t_1: \quad R_{1_{t_1 t_1}}(t_1, t_2; \beta_1, \beta_2, a) < 0 \qquad (13)$$

The problem of the region 2 can also be formulated in a similar way.

The Symmetric Nash equilibrium

Since the two regions are symmetric, it is possible to show that a symmetric Nash equilibrium exists and satisfies the two following conditions obtained from the FOCs of the first two *stages* imposing $t_1 = t_2 = t,\ \beta_1 = \beta_2 = \beta$[14]:

$$\beta: \quad r'_\beta = -2n'_\beta \times r > 0 \quad \Rightarrow \quad B \times \frac{\partial \theta}{\partial \beta} - d'(\beta) = r \times \frac{B \times \left(\frac{\partial \theta}{\partial \beta} + \frac{\partial g}{\partial \beta}\right)}{a} \qquad (14)$$

[14] These conditions imply $n_1 = n_2 = n = \frac{1}{2}, r_1 = r_2 = r, \theta_1 = \theta_2 = \theta, g_1 = g_2 = g$.

$$t: \quad r_t' = -2n'_t \times r > 0 \qquad \Rightarrow \qquad B \times \frac{\partial\theta}{\partial t} = r \times \frac{B \times \left(\frac{\partial\theta}{\partial t} + \frac{\partial g}{\partial t}\right)}{a} \tag{15}$$

In the conditions (14) and (15) the factor $-2n'_j$ represents the expected loss in the number of taxpayers due to an increase in $j = \beta, t$. So the right hand side of both equations corresponds to the marginal mobility costs for the regional governments in term of tax revenue losses respectively due to an increase in β or in t. The left hand side represents the net marginal revenue due to an increase in β or in t.

Developing the conditions (14) and (15) it is immediate to show that in the limit case of centralization $(a \to +\infty)$, the marginal mobility costs are null and results that $r_\beta' = r_t' = 0$: we are in the bliss point of the Laffer curve. Since the marginal mobility costs are positive, under decentralization $(a \in (0, +\infty))$ the tax policies implementation is more costly. In fact the net marginal tax revenues are positive $(r_\beta' > 0, r_t' > 0)$ and the tax policies are less severe than under centralisation: the tax-base mobility threat tames the Leviathan.

The slope of the reaction function and other comparative statics

Since the purpose of this paper is to empirically test the presence of regional interdependencies in the setting of tax auditing policies, we want to investigate the process that regional administrations face in order to reach the equilibrium level of the auditing probability. That is we are interested in evaluating the slope of the reaction function $\beta_i(\beta_j)$. A non null sign would highlight the presence of some kind of interactions among regions. In particular we expect to find a positive sign, i.e. following the game-theory literature, we expect β_i and β_j to be strategic complements. This result would better clarify that, in a decentralized framework, the lower equilibrium level in β is the consequence of a competition process due to the potential tax base mobility.

Applying the implicit function theorem to the expression (9a) and holding the condition (10a) it is easy to show that:

$$\frac{\partial\beta_1}{\partial\beta_2} = -\frac{R_{1_{\beta_1\beta_2}}(\beta_1, \beta_2; t_1, t_2, a)}{R_{1_{\beta_1\beta_1}}(\beta_1, \beta_2; t_1, t_2, a)} = -\frac{\frac{\partial n_1}{\partial\beta_2} \times \frac{\partial r_1}{\partial\beta_1}}{2\frac{\partial n_1}{\partial\beta_1} \times \frac{\partial r_1}{\partial\beta_1} + n_1 \times \frac{\partial^2 r_1}{\partial{\beta_1}^2} + r_1 \times \frac{\partial^2 n_1}{\partial{\beta_1}^2}} > 0 \tag{16}$$

As expected the slope of the reaction function is positive: the regional administrations set the auditing strategies in a complementary way and so they are competing on this instrument in order to attract (or to not lose) tax bases. In particular, the higher is the level of $\frac{\partial\beta_1}{\partial\beta_2}$, the stronger is the competition on the auditing policies.

Moreover it is possible to show that $\frac{\partial\left(\frac{\partial\beta_1}{\partial\beta_2}\right)}{\partial a} < 0$ (please see Appendix 1 for details). This means that the competition between regions become weaker when the mobility costs are higher. This is a reasonable result that can lead to some further comments. For instance, if we realistically suppose that the mobility costs are positively correlated with the distance between the regions, we can stress that two far regions will compete less than two closer regions[15].

Whether a relationship between the level of tax auditing competition and the level of tax rates competition exists is another interesting issue to analyze. To investigate this problem it is possible to study how $\frac{\partial\beta_1}{\partial\beta_2}$ reacts to a variation of t_2, i.e. to study the sign of $\frac{\partial\left(\frac{\partial\beta_1}{\partial\beta_2}\right)}{\partial t_2}$. This measures whether the administration of a region react to a change in the tax rate set by the government of the other region, when setting the auditing policy. If $\frac{\partial\left(\frac{\partial\beta_1}{\partial\beta_2}\right)}{\partial t_2} = 0$ it means that there is no reaction. A positive sign would mean that increasing competition on tax rates $(t_2 \downarrow)$ would reduce the competition on auditing probabilities $\left(\frac{\partial\beta_1}{\partial\beta_2}\downarrow\right)$, i.e. the slope of the reaction function $\beta_1(\beta_2)$ would be still positive but lower in absolute value. A negative sign would lead to the opposite implications. Actually it is not possible to univocally determine the sign of $\frac{\partial\left(\frac{\partial\beta_1}{\partial\beta_2}\right)}{\partial t_2}$ (see Appendix 3 for details) but as long as $\frac{\partial\left(\frac{\partial\beta_1}{\partial\beta_2}\right)}{\partial t_2} \neq 0$, some kind of interaction between different institutions of different regions is present when setting their respective policies.

It is also possible to perform some more comparative statics in order to highlight the strategic relationship between β_1 and $t_i\,;\; i = 1,2$.

First of all we have that:

$$\frac{\partial\beta_1}{\partial t_1} = -\frac{R_{1_{\beta_1 t_1}}(\beta_1,\beta_2;t_1,t_2,a)}{R_{1_{\beta_1\beta_1}}(\beta_1,\beta_2;t_1,t_2,a)} \gtreqless 0 \qquad (17)$$

This means that it is not possible to unambiguously establish if β_i and t_i are strategic complements or strategic substitutes[16]. The source of this uncertainty could be interpreted in terms of externalities. In this framework the main externality is due to the horizontal "mobility-based" competition process that takes places among regions when fixing their tax policies but, allowing for two different levels of policy making, we are also implicitly introducing a vertical externality between any regional government and its administration. In terms of horizontal externalities both

[15] From an empirical point of view, this hypothesis could be tested by means of a specific spatial matrix built on the basis of the distances between regions.

[16] In general in presence of mobility, i.e. when $a\epsilon(0,+\infty)$, β_i and t_i are strategic complements when:

$$\frac{\partial\beta_1}{\partial t_1} > 0 \;\Leftrightarrow\; \frac{\partial^2 r_1}{\partial\beta_1 t_1}\times n_1 > -\left(\frac{\partial n_1}{\partial t_1}\times\frac{\partial r_1}{\partial\beta_1} + \frac{\partial^2 n_1}{\partial\beta_1 t_1}\times r_1 + \frac{\partial r_1}{\partial t_1}\times\frac{\partial n_1}{\partial\beta_1}\right).$$

levels of local institutions aims at keeping tax bases in their region, maintaining the effective tax rate $\theta_i$constant. So in this sense the horizontal externality push for $\frac{\partial \beta_1}{\partial t_1} < 0$. On the other hand if the regional government increases the tax rate, the administration expects a higher level of tax evasion and, in order to keep it constant, reacts rising the level of tax auditing. So the net variation due to the vertical externality is $\frac{\partial \beta_1}{\partial t_1} > 0$. It is not possible to establish which of these two effects will prevail.

In the limit case of a centralized framework $(a \rightarrow +\infty)$ only vertical externality matters and results that $\frac{\partial \beta_1}{\partial t_1} > 0$: β_1 and t_1 are strategic complements.

In any case β_1 and t_2 are strategic complements, in fact:

$$\frac{\partial \beta_1}{\partial t_2} = -\frac{R_{1_{\beta_1 t_2}}(\beta_1, \beta_2; t_1, t_2, a)}{R_{1_{\beta_1 \beta_1}}(\beta_1, \beta_2; t_1, t_2, a)} = -\frac{\frac{\partial n_1}{\partial t_2} \times \frac{\partial r_1}{\partial \beta_1}}{R_{1_{\beta_1 \beta_1}}(\beta_1, \beta_2; t_1, t_2, a)} > 0 \qquad (18)$$

This result is reasonable in the sense that if the government of one region increases the competition on the tax rates $(t_j \downarrow)$, ceteris paribus, the administration of the other region will unambiguously react setting a more tolerant auditing rate $(\beta_i \downarrow)$ in order to not loose tax bases.

4. Empirical Analysis

In this section we provide the main hypothesis to be tested by means of an econometric model, we give a description of the data base and we present and comment the main results that arise from the analysis.

The empirical framework

The theoretical framework presented in the previous section offers interesting insights to be empirically tested: the horizontal tax competition model suggests that revenues maximizing administrations set the auditing policies in a complementary way, interacting between them in order to not loose tax bases. This result comes from equation (16). In order to test this hypothesis our main research question is: Are regional administration authorities interacting between them? Before to try to answer this question we want to perform a basic characterization of the determinants of the size of the regional tax administration[17]. In this sense we assume that an optimal size of the tax administration exists if the tax auditing rate, $TAR \equiv \frac{\#Audits}{\#\,Tax\ Return}$, is not affected by a change in the number of tax return, i.e. at a change in the number of tax return corresponds a proportional change in the number of audits. We test this hypothesis using the following model:

[17] The literature that deals with the setting of the tax administration parameters is relatively scarce. In particular there is no accordance on which is the objective function that the administrative institutions maximize. The dominant approach design it as a public agency that maximize tax revenues (see for instance, Shaw Slemrod, Whiting 2009; Slemrod, Yitzhaki 2002, 1987). Recently some empirical papers suggest that also the political variables matter (see e.g. Esteller-Moré, 2005).

$$TAR_{it} = \alpha + \beta TR_{it} + \delta \boldsymbol{X_{it}} + \vartheta_i + \tau_t + \varepsilon_{it} \qquad (E1)$$

We work with mobile means and take the logarithm of the variables that are not expressed in percentages. So TAR_{it} is the logarithm of the mean of the tax auditing rate of region i with respect to year t and $(t-1)$[18]. The main regressor is TR_{it} that represents the number of tax return. The specification includes a vector $\boldsymbol{X_{it}}$ of suitable controls and fixed effects for regions ϑ_i and years τ_t, while ε_{it} is the error term.

If the size of tax administration is optimal we expect β to be equal to zero, while if it is negative (positive) this means that the size of tax administration is too small (too big).

The size of tax administration could be sensible to "income" and "political" effects as to other elements: we control for these factors through a vector $\boldsymbol{X_{it}}$ of several variables. el_{it}, a dummy variable equal to one if there is an election in region i during the year t, is introduced to control for the electoral cycle. $left_{it}$ is another dummy equal to one if the government in chair in a specific region and year is "leftish". This variable is expected to be positively related to TAR_{it} because a left wing government is supposed to be ideologically sensible to this kind of tax. We use the per capita GDP ($gdppc_{it}$) to control for the economic cycle. The deficit-gdp ratio ($defgdp_{it}$) and the total amount of transfers received from the central government divided by the total regional expenditure ($transfexp_{it}$) are introduced to account for further relevant budgetary factors. In particular $defgdp_{it}$ is expected to be negatively correlated with TAR_{it} because if the deficit increases, the tax administration could represent an instrument to obtain more budgetary resources. On the other hand $transfexp_{it}$ is expected to negatively affect TAR_{it} because the higher is the amount of contribution received from the central government, the lower is the expected effort implemented by the local government to obtain own-regional funds. We also control for a measure of Tax Capacity, the total IGT revenues divided by the number of tax return ($prft_{it}$) and a measure of profitability (im_actas_{it}) defined as the mean revenue per audit. Moreover we include a dummy (ext_{it}) equal to one if the regional government i introduced during the year t a sensible modification in the deduction regime in favour of the most common inheritors. Finally we include a variable that accounts for the learning-innovation process in the tax administration: the "learning by doing" (lbd_{it}) that for each year account for the number of years passed from the first administration period.

The previous model might still be misspecified because, as we guess, tax interactions among regions may play a role in determining the size of the tax administration. Then we return to the main research question:

[18] Since the ratio between the total number of audits and the total number of tax returns is naturally defined between 0 and 1, a possible extension of the model could be implemented using a spatial discrete choice procedure.

To what extent the auditing policy of each region depends on the strategies adopted by the other regions?

To answer this question we adopt a basic spatial econometrics specification (see Anselin, 2007; Brueckner, 2003):

$$TAR_{it} = \alpha + \gamma TAR_{-it} + \beta TR_{it} + \delta \boldsymbol{X_{it}} + \vartheta_i + \tau_t + \varepsilon_{it} \qquad (E2)$$

Where $TAR_{-it} \equiv \sum_{j=1}^{N} w_{ij}\, TAR_{jt}$. So γ is the autoregressive coefficient and w_{ij} is the spatial weight that reports the relative interdependence between regions i and j. If the coefficient γ results significantly different from zero, the model will predict the presence of regional interactions in the setting of tax auditing policies. In particular according to theoretical framework, eq. (16), we expect γ to be positive.

Moreover, given a positive γ, if β is now not significantly different from zero this means that controlling for horizontal competition the size of the administration is optimal. This would be congruent with the theoretical model: equation (14) predicts that in a federal framework the size of the tax administration is smaller than in a centralized one because the tax-base mobility threat tames the administrators. And this would also mean that in absence of competition the size of tax administration could be theoretically optimal. On the other hand, a still negative β is congruent with structural sub-optimality of tax administration: the horizontal tax competition reduces the size of the tax administration but not in a fundamental way. This means that even in absence of tax competition the size of tax administration would be sub-optimal and this could be due in part to budgetary and political issues but also to a general lack of interest of the regional institutions regarding this tool.

A main estimation concern, regarding the endogeneity of the main regressor TAR_{-it}, merits discussion. According to the theoretical framework, regional administrations choose their policies simultaneously rising issues about the direction of the causation. Moreover the setting of these auditing tools might be influenced by unobserved shocks. A first, rough measure to circumvent this problem is to control for regional and time effects in order to remove all the unobserved time invariant region-specific factor as well as annual shocks that affect the choice of the administrative strategies. A more formal approach is to instrument TAR_{-it}. Following the methodology applied in previous studies (Figlio et al., 1999; Fredriksson and Millimet, 2002a, 2002b) we use a subset of the variables in $\boldsymbol{X_{it}}$ as instruments employing the same weighting scheme for the instruments as we do for TAR_{-it}. In addition we report cluster-robust standard errors. A following strategy would be to introduce a time lag in the main regressor TAR_{-it} (Millimet Rangaprasad, 2007).

Data and Sources

Our panel is constituted by the information about the 15 Spanish autonomous communities for the period 1986-1992 and 1994-2009[19] The main variable, Tax Auditing Rate, together with the number of Tax Return and the proxy of profitability (im_actas_{it}), is extracted from the report "Informe sobre la cesión de tributos a las Comunidades Autónomas" annually published with the Spanish National Budget "Presupuestos Generales del Estado". The other variables are obtained from different statistical sources.

The per capita GDP ($gdppc_{it}$) is extracted from the Spanish National Institute of Statistics, INE. The deficit data used to construct the variable $defgdp_{it}$ is calculated as the difference between current availability and current expenditure extracted from the Ministry of the Economy and Finance database. The $transfexp_{it}$ is constructed as the ratio between the total amount of transfers received from the central government (extracted from the INE database) and the total regional expenditure (extracted from the Ministry of the Economy and Finance database).

The measure of Tax Capacity, $prft_{it}$, is constructed as the ratio between the total IGT revenues (extracted from the INE database) divided by the number of tax return.

The election years, el_{it}, are obtained from the Interior Ministry website (http://www.mir.es/DGPI/Elecciones/Procesos_Electorales_Celebrados/proceso_por_tipoyfecha.html) The information about the political colour of the regional governments necessary to construct the dummy $left_{it}$ is obtained from Zarate's Political Collections (http://www.terra.es/personal2/monolith).

The information to construct the dummy ext_{it} that accounts for the introduction of exemptions is extracted from Duran Esteller (2009).

Variable	***mean***	***median***	***sd***	***max***	***Min***
Tax Auditing Rate	0.0200951	0.01171	0.0272	0.1969	0
Tax Return	21187	13442	18235	88528	1641
Transfers/tot expenditure	0.3977149	0.38537	0.1348	1.3739	0.11171
Deficit/GDP	-0.0028976	-0.0018	0.0071	0.0299	-0.0261
per capita GDP	11.52553	11.3535	5.4972	23.017	2.17458
Tax Capacity	0.0022669	0.00196	0.0015	0.0103	0.00037
Profitability	7.942521	4.52035	9.7662	73.803	0
Election	0.2546584	0	0.4363	1	0
Left	0.4627329	0	0.4994	1	0
Exemption	0.1335404	0	0.3407	1	0

Table 5: Summary statistics

[19] The information about auditing in the Madrid community starts from 1996 because this is the year in which it received the administrative power. tax administration policies are published together with the annual national budget and the information presented in any budget is two year lagged. We don't have information about the administration policies in 1993 because in 1995 the budget was not approved.

Results and further developments

In Table 2 are presented the results regarding the tax administration size analysis. We obtained a negative statistically significant estimate for the parameter β: the size of the tax administration is sub-optimal. This could be due to several reasons. In particular this could depend on political-ideological issues, "income effects" or other sources of heterogeneity. For what concern the political and ideological issues we do not find any significant effect: the variables $left_{it}$, el_{it} and also the dummy ext_{it} are not significantly different from zero. Regarding the possible income effects, we control for budgetary variables and we obtain that some of them play a role in determining the size of tax administration. Anyway since the parameter β is still negative and significant, these income effects should not be the main effects at work when explaining the size of tax administration.

As expected the variable $defgdp_{it}$ is significant and positive. This means that in the regions where the expected deficit is pretty worrying, the tax administration is higher in the sense that represents an instrument to obtain more budgetary resources.

As we previously guessed the variable $trfexp_{it}$ is significant and negative: on the other hand the higher is the amount of contribution received from the central government, the lower is the effort implemented by the local government to obtain own-regional funds through the tax administration.

Also im_actas_{it-1} is significant and negative: as higher are the revenues per audit collected in the previous period as lower will be the administration in the current period. This is a measure of efficiency in the tax administration activity.

Among the other sources of heterogeneity, the proximity to "foral communities" results to be strongly significant and it is associated with a very small size of the tax administration[20]. This is interesting because in the foral communities the IGT has been substantially eliminated since a lot of time, and so this result could mean that at least in that area the competition between regional administrations could matter. This opens the possibility of a misspecified model for this reason we formally introduce competition in the analysis. In any case a lack of interest for this policy tool could still play a role in determining the sub-optimal size of tax administration.

In Table 3 we present the results of the regression expressed in equation $(E2)$, explicitly including horizontal tax competition on TAR_{it}. We found that the autoregressive coefficient is significant and positive: this is congruent with the theoretical model. The coefficient of TR_{it} is no more significantly different from zero: this means that controlling for horizontal tax competition the size of tax administration results optimal. In this sense the horizontal tax competition conditions the size of the tax administration but not in a structural way. Moreover, this means that as long as tax audit competition was not at work, the size of tax administration would be theoretically optimal.

[20] We consider an interaction term between the variable $logtr_{it}$ and a dummy for the neighbours of the foral communities (Aragon, Castilla Leon, La Rioja and Cantabria).

This result could be interpreted in this way: regional administrators can potentially keep TAR_{it} constant, but the number of audits is below its optimal value due to the tax-base mobility threat: as the theoretical model predicts, the regional administrations are tamed by the horizontal tax competition.

Anyway we think that the autoregressive coefficients that the model estimates are too high in absolute value and they are not credible. In fact even if there are not specific papers analyzing these issues with which compare these estimates, the closer literature on spatial interactions in local tax rates setting suggests that the slope of the reaction function should be pretty lower[21] (Revelli, 2001, 2006). For this reason we think that there could be a misspecification of the model and that further development and checks are needed. In this line we tried to enrich the model in a parsimonious way introducing several interactions between the autoregressive variable and other controls (time periods dummies for the two reform of 1997 and 2001, leftish government dummy, deficit) without obtaining significant estimates. For this reason we think that is necessary a more structural change in the framework. The simplest way is consider a different spatial matrix e.g. based on the (inverse of the) distance between regional capitals. Even if the literature suggests that a change in the spatial matrix shouldn't be crucial (LeSage, Pace 2010) in our case the model could be better specified because of the islands cases that make the choice of the neighbours quite arbitrary[22].

A stronger extension of the model will be obtained thinking that TAR_{it} could depend in part on its values in previous periods. Formally this extension leads the model to be dynamic.

5. Conclusions

The tax administration has scarcely been considered as an integral part of the decision-making process however how taxes are administered and enforced matters. In this paper we have shown that in a federal framework this could represent an ulterior instrument on which regional institutions can interact in addition to the tax rate.

We developed a horizontal tax competition model with two tax instruments: the tax rate and the tax auditing rate in order to empirically test its findings. The results of this theoretical framework, for what concern the tax auditing rate, are in line with the literature on tax rates competition.

The mobility threat tames the Leviathan administrations that compete in a race to the bottom in order to not lose the tax bases. Moreover we find that the slope of the administration's reaction function is positive and that the higher are the taxpayer's mobility costs the weaker will be the competition. These results have been tested through a spatial econometric model. In this sense, in order to better describe these issues we have preliminarily performed an analysis of the determinants of the tax administration size. The main results are the following: without controlling for the horizontal tax competition, the tax administration size is suboptimal and it is not

[21] They should be around 0.2 – 0.35.

[22] For the moment we assumed that the Balearic Islands' neighbours are Catalonia and the Valencian communities and that the neighbor of Canary islands is Andalusia because this is the "closer" region.

homogeneous across regions since the foral communities' neighbours seemed to be affected by more structural problems of sub-optimality of the tax administration size. Some of the budgetary variables have a good explicative power but it seems that they don't represent the main effect at work when explaining tax administration size. For this reason we formally introduced the tax competition. Testing for spatial interactions corroborates the horizontal tax competition hypothesis provided by the theoretical model. Moreover, controlling for horizontal tax competition, the size of tax administration results optimal. This means that in absence of tax audit competition, the size of tax administration would be optimal: the regional administrations are tamed by the mobility threat.
Anyway, since the estimate of the autoregressive coefficient is not credible (because is too high), we think that these partial results could be heavily enhanced by further analysis that call for a dynamic specification of the model.

Table 2: tax administration size

	(1) logmda	(2) Logmda	(3) logmda	(4) logmda	(5) Logmda	(6) Logmda
Logtr	-1.701***	-1.863***	-1.326**	-1.871***	-1.059**	-0.987*
	(-2.657)	(-2.902)	(-2.126)	(-2.830)	(-1.994)	(-1.733)
Left	0.121	0.123	0.233	0.105	0.100	0.146
	(0.603)	(0.615)	(1.189)	(0.519)	(0.598)	(0.884)
el	0.177	0.167	0.148	0.182	0.117	0.108
	(0.862)	(0.821)	(0.752)	(0.891)	(0.686)	(0.651)
ext	-0.251	-0.216	0.086	-0.178	-0.385	-0.099
	(-0.831)	(-0.718)	(0.284)	(-0.583)	(-1.529)	(-0.385)
defgdp	37.507***	36.536***	32.002**	36.906***	47.248***	40.580***
	(2.934)	(2.874)	(2.583)	(2.876)	(4.311)	(3.731)
trfexp	-1.346*	-0.506	-1.578**	-1.345*	-1.422**	-1.566**
	(-1.819)	(-0.590)	(-2.208)	(-1.821)	(-2.282)	(-2.057)
llogprft	-0.088	-0.010	0.019	-0.090		0.037
	(-0.334)	(-0.039)	(0.075)	(-0.344)		(0.170)
loggdppc	2.762	2.992	3.486	2.218	1.614	1.846
	(1.121)	(1.221)	(1.464)	(0.893)	(0.772)	(0.882)
MDlogtr_trfexp		1.977*				0.305
		(1.898)				(0.278)
logtr_dforal			-2.470***			-1.833***
			(-4.105)			(-3.331)
logtr_mid				-0.198		-0.052
				(-1.011)		(-0.265)
logtr_post01				0.121		0.149
				(0.649)		(0.947)
loglim_actas					-0.355***	-0.323***
					(-4.853)	(-4.478)
_cons	6.460	7.861	8.931	8.728	3.440	7.148
	(0.923)	(1.124)	(1.319)	(1.206)	(0.581)	(1.190)
Fixed Effects	YES	YES	YES	YES	YES	YES
Time Effects	YES	YES	YES	YES	YES	YES
N	244	244	244	244	238	238
R^2	0.424	0.434	0.468	0.431	0.533	0.570
adj. R^2	0.317	0.325	0.366	0.319	0.444	0.474

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Testing Horizontal tax competition; "neighbors' weight" for spatial lag

	(1)	(2)	(3)
	logmda	logmda	Logmda
logWmda	0.806*	0.812*	1.105**
	(1.707)	(1.809)	(2.299)
logtr	-0.594	-0.652	-0.587
	(-0.883)	(-1.115)	(-0.963)
defgdp	30.401**	29.888*	35.340**
	(2.001)	(1.907)	(2.238)
trfexp	-1.564**	-1.549**	-2.044***
	(-2.178)	(-2.219)	(-2.975)
loggdppc	4.235*	3.853	3.661
	(1.766)	(1.521)	(1.423)
logtr_dforal	-2.282***	-2.198***	-3.669***
	(-3.509)	(-3.356)	(-4.384)
loglim_actas	-0.338***	-0.332***	-0.298***
	(-2.889)	(-2.844)	(-2.682)
logtr_mid		0.025	-0.063
		(0.148)	(-0.361)
logtr_post01		0.290	0.388*
		(1.519)	(1.956)
logWmda_dforal			-1.046***
			(-2.957)
Fixed Effects	YES	YES	YES
Time Effects	YES	YES	YES
N	238	238	238
R^2	0.438	0.444	0.470
adj. R^2	0.328	0.332	0.360
Endog chi^2	8.879	6.513	7.107
p-value	0.003	0.011	0.008
Hansen J statistic	2.189	1.888	1.181
p-value	0.701	0.756	0.881

Appendix 1: Comparative statics on a

It is possible to express $\frac{\partial \beta_1}{\partial \beta_2}$ as a function of a in order to perform a comparative statics:

$$\frac{\partial \beta_1}{\partial \beta_2} = -\frac{N}{A + a \times \frac{\partial^2 r_1}{\partial {\beta_1}^2}} = -N \times \left(A + a \times \frac{\partial^2 r_1}{\partial {\beta_1}^2}\right)^{-1} \tag{A1}$$

Where:

$$A = -2B \times \left[\frac{\partial \theta_1}{\partial \beta_1} + \frac{\partial g_1}{\partial \beta_1}\right] \times \left[B \times \frac{\partial \theta_1}{\partial \beta_1} - d'(\beta_1)\right] + B \times [\theta_2 - \theta_1 + g_2 - g_1] \times \left[B \times \frac{\partial^2 \theta_1}{\partial {\beta_1}^2} - d''(\beta_1)\right] - [B \times \theta_1 - d(\beta_1)] \times B \times \left[\frac{\partial^2 \theta_2}{\partial {\beta_1}^2} + \frac{\partial^2 g_2}{\partial {\beta_1}^2}\right] \tag{A2}$$

and

$$N = B \times \left[\frac{\partial \theta_2}{\partial \beta_2} + \frac{\partial g_2}{\partial \beta_2}\right] \times \left[B \times \frac{\partial \theta_1}{\partial \beta_1} - d'(\beta_1)\right] \tag{A3}$$

Results that under conditions (16a) and (17a), $N > 0$ and:

$$\frac{\partial \left(\frac{\partial \beta_1}{\partial \beta_2}\right)}{\partial a} = \frac{N}{\left(A + a \times \frac{\partial^2 r_1}{\partial {\beta_1}^2}\right)^2} \times \frac{\partial^2 r_1}{\partial {\beta_1}^2} < 0 \tag{A4}$$

Appendix 2: Generalized results with not uniform distribution of taxpayers

Now we assume that the distribution of taxpayers along the home attachment is not uniform, i.e. we assume that $n \in (0,1) \sim f(n)$ where $f(n)$ represents a generic density function. Graphically we have that:

[figure about here]

The value $n_1(t_1, \beta_1, t_2, \beta_2; a) = \frac{1}{2} + \frac{{U_1}^* - {U_2}^*}{2a}$ represents the marginal individual indifferent between living in region 1 and region 2. Below n_1 we have all the taxpayers that settle in region 1, while above n_1 there are all the taxpayers that live in region 2. The respective shares of each group are $F(n_1)=\int_0^{n_1} f(n)dn$ and $1-F(n_1)=\int_{n_1}^{1} f(n)dn$.

At *stage* 2 the problem of the administration of region 1 becomes:

$$\underset{\beta_1}{Max}\ R_1 = F(n_1)\times r_1 = F(n_1)\times[B\times\theta_1 - d(\beta_1)]$$

The FOC of this problem is:

$$n_1{}'_{\beta_1}\times f(n_1)\times r_1 + r'_{1\beta_1}\times F(n_1) \equiv P(\beta_1,\beta_2;t_1,t_2,a)=0$$

The SOC is:

$$P_{\beta_1}(\beta_1,\beta_2;t_1,t_2,a)<0$$

The slope of the reaction function becomes:

$$\frac{\partial\beta_1}{\partial\beta_2} = -\frac{P_{\beta_2}(\beta_1,\beta_2;t_1,t_2,a)}{P_{\beta_1}(\beta_1,\beta_2;t_1,t_2,a)}$$

That is positive as long as $f'(n_1)\le 0$.

Appendix 3: Interdependencies between different instruments

The derivative $\frac{\partial\beta_1}{\partial\beta_2}$ with respect to t_2 could be written as:

$$\frac{\partial\left(\frac{\partial\beta_1}{\partial\beta_2}\right)}{\partial t_2} = \frac{-R_{1_{\beta_1\beta_2t_2}}\times R_{1_{\beta_1\beta_1}} + R_{1_{\beta_1\beta_1t_2}}\times R_{1_{\beta_1\beta_2}}}{\left(R_{1_{\beta_1\beta_1}}\right)^2}$$

That is positive as long as:

$$M \equiv R_{1_{\beta_1\beta_1t_2}}\times R_{1_{\beta_1\beta_2}} - R_{1_{\beta_1\beta_2t_2}}\times R_{1_{\beta_1\beta_1}} > 0 \iff R_{1_{\beta_1\beta_1t_2}}\times R_{1_{\beta_1\beta_2}} > R_{1_{\beta_1\beta_2t_2}}\times R_{1_{\beta_1\beta_1}}$$

Where:

$R_{1_{\beta_1\beta_1t_2}} = \frac{\partial n_1}{\partial t_2}\times\frac{\partial^2 r_1}{\partial{\beta_1}^2} < 0$,

$R_{1_{\beta_1\beta_1}} = 2\frac{\partial n_1}{\partial\beta_1}\times\frac{\partial r_1}{\partial\beta_1} + n_1\times\frac{\partial^2 r_1}{\partial{\beta_1}^2} + r_1\times\frac{\partial^2 n_1}{\partial{\beta_1}^2} < 0$ under the SOC;

$R_{1_{\beta_1\beta_2t_2}} = \frac{\partial^2 n_1}{\partial\beta_2 t_2}\times\frac{\partial r_1}{\partial\beta_1} > 0$ under FOC;

$R_{1\beta_1\beta_2} = \frac{\partial n_1}{\partial t_2} \times \frac{\partial r_1}{\partial \beta_1} > 0$ under FOC.

So in general it is not possible to establish an unambiguous relationship between $\frac{\partial \beta_1}{\partial \beta_2}$ and t_2.

Appendix 4: Regional governments simultaneously set both tax instruments

If both policies are set by the same agent the model is developed in three *stages*:

1. Regional governments set tax rates and tax auditing policies.
2. Taxpayers decide in which region set their location.
3. Taxpayers decide their level of tax evasion.

This new schedule doesn't affect the results at stages 2 and 3.

At the first *stage* we have that region 1 faces the following problem anticipating the results of the last two *stages*:

$$\underset{t_1, \beta_1}{Max}\ R_1(t_1, \beta_1, t_2, \beta_2; a) = n_1 \times r_1 = \left(\frac{1}{2} + \frac{B \times [\theta_2 - \theta_1 + g_2 - g_1]}{2a}\right) \times [B \times \theta_1 - d(\beta_1)]$$

So the FOCs are:

$$\beta_1: \quad r'_{1\beta_1} \times n_1 + n'_{1\beta_1} \times r_1 \equiv G_1(t_1, \beta_1, t_2, \beta_2) = 0$$

$$t_1: \quad r'_{1t_1} \times n_1 + n'_{1t_1} \times r_1 \equiv G_2(t_1, \beta_1, t_2, \beta_2) = 0$$

The SOCs holds if the Hessian matrix of the second derivatives is negative definite that holds if and only if:

$$\frac{\partial G_1}{\partial \beta_1} < 0, \quad \frac{\partial G_2}{\partial t_1} < 0$$

and

$$\frac{\partial G_1}{\partial \beta_1} \times \frac{\partial G_2}{\partial t_1} - \frac{\partial G_1}{\partial t_1} \times \frac{\partial G_2}{\partial \beta_1} > 0$$

Assuming that both policies are set by the same agent doesn't affect the symmetric equilibrium results but complicate the evaluation of $\frac{\partial \beta_1}{\partial \beta_2}$. In fact it is possible to apply the Implicit Function Theorem to the FOCs in order to obtain:

$$\frac{\partial\beta_1(t_2,\beta_2)}{\partial\beta_2} = -\frac{\frac{\partial G_2}{\partial t_1}\times\frac{\partial G_1}{\partial \beta_2} - \frac{\partial G_1}{\partial t_1}\times\frac{\partial G_2}{\partial \beta_2}}{\frac{\partial G_1}{\partial \beta_1}\times\frac{\partial G_2}{\partial t_1} - \frac{\partial G_1}{\partial t_1}\times\frac{\partial G_2}{\partial \beta_1}} \equiv \Phi(t_1,\beta_1,t_2,\beta_2)$$

It is clear that we have to consider both the direct effect of β_2 on β_1 and the indirect effect due to a variation of t_1 with respect to β_2 that still affect β_1.

In particular it is possible to show that under the FOCs and under the SOCs, $\Phi(t_1,\beta_1,t_2,\beta_2) > 0$ if and only if $\frac{\partial G_1}{\partial t_1}\times\frac{\partial G_2}{\partial \beta_2} > \frac{\partial G_2}{\partial t_1}\times\frac{\partial G_1}{\partial \beta_2}$[23].

Appendix 5: Derivatives computation

From equations (2) and (3) and by means of the implicit function theorem it is possible to show that:

$$\frac{\partial\alpha^*{}_i}{\partial t_i} = \frac{\partial\alpha^*(t_i,\beta_i)}{\partial t_i} = \frac{-(1-\beta_i\times\tau)}{g''} < 0$$

$$\frac{\partial\alpha^*{}_i}{\partial \beta_i} = \frac{\partial\alpha^*(t_i,\beta_i)}{\partial \beta_i} = \frac{t_i\tau}{g''} > 0$$

From these results and the equations (6) and (8) we have that:

$$\frac{\partial\theta_i{}^*}{\partial t_i} = \alpha^*{}_i + (1-\alpha^*{}_i)\times\beta_i\times\tau + \frac{\partial\alpha^*{}_i}{\partial t_i}\times(1-\beta_i\times\tau)\times t_i \lessgtr 0$$

$$\frac{\partial\theta_i{}^*}{\partial \beta_i} = (1-\alpha^*{}_i)\times t_i\times\tau + \frac{\partial\alpha^*{}_i}{\partial \beta_i}(1-\beta_i\times\tau)\times t_i > 0$$

$$\frac{\partial g_i}{\partial t_i} = -\frac{\partial\alpha^*{}_i}{\partial t_i}(1-\beta_i\times\tau)\times t_i > 0$$

$$\frac{\partial g_i}{\partial \beta_i} = -\frac{\partial\alpha^*{}_i}{\partial \beta_i}(1-\beta_i\times\tau)\times t_i < 0$$

$$\left[\frac{\partial\theta_i{}^*}{\partial t_i} + \frac{\partial g_i}{\partial t_i}\right] = \alpha^*{}_i + (1-\alpha^*{}_i)\times\beta_i\times\tau > 0$$

[23] Devereux et al (2008) face a similar problem in which the policymaker simultaneously set two instruments. In order to univocally determine the strategic relationship between these instruments they make some assumptions. Replicating their assumption would mean to assume $\frac{\partial G_2}{\partial \beta_2} = 0$, i.e. to assume that there isn't any direct strategic effect of β_2 on t_2 but we know that the direct effect is positive because $\frac{\partial G_2}{\partial \beta_2} > 0$. So we cannot replicate their procedure.

$$\left[\frac{\partial \theta_i{}^*}{\partial \beta_i} + \frac{\partial g_i}{\partial \beta_i}\right] = (1 - \alpha^*{}_i) \times t_i \times \tau > 0$$

$$\frac{\partial n_1}{\partial \beta_1} = -\frac{B \times \left[\frac{\partial \theta_1}{\partial \beta_1} + \frac{\partial g_1}{\partial \beta_1}\right]}{2a} < 0$$

$$\frac{\partial n_1}{\partial \beta_2} = \frac{B \times \left[\frac{\partial \theta_2}{\partial \beta_2} + \frac{\partial g_2}{\partial \beta_2}\right]}{2a} > 0$$

$$\frac{\partial n_1}{\partial t_1} = -\frac{B \times \left[\frac{\partial \theta_1}{\partial t_1} + \frac{\partial g_1}{\partial t_1}\right]}{2a} < 0$$

$$\frac{\partial n_1}{\partial t_2} = \frac{B \times \left[\frac{\partial \theta_2}{\partial t_2} + \frac{\partial g_2}{\partial t_2}\right]}{2a} > 0$$

$$\frac{\partial r_1}{\partial \beta_1} = \left[B \times \frac{\partial \theta_1}{\partial \beta_1} - d'(\beta_1)\right] \lesseqgtr 0$$

$$\frac{\partial r_1}{\partial t_1} = \left[B \times \frac{\partial \theta_1}{\partial t_1}\right] \lesseqgtr 0$$

$$\frac{\partial^2 \alpha^*(t_i, \beta_i)}{\partial \beta_i{}^2} = \frac{\frac{\partial \alpha^*}{\partial \beta_i} \times \tau \times t_i}{(g'')^2} \times g''' \leq 0 \quad iff \quad g''' \leq 0$$

$$\frac{\partial^2 \alpha^*(t_i, \beta_i)}{\partial t_i{}^2} = \frac{\frac{\partial \alpha^*}{\partial t_i} \times (1 - \beta_i \times \tau)}{(g'')^2} \times g''' \leq 0 \quad iff \quad g''' \geq 0$$

We assume $g''' = 0$.

$$\frac{\partial^2 \theta_i{}^*}{\partial t_i{}^2} = \frac{\partial \alpha^*}{\partial t_i} \times 2 \times (1 - \beta_i \times \tau) + \frac{\partial^2 \alpha^*}{\partial t_i{}^2}(1 - \beta_i \times \tau) \times t_i < 0 \quad iff \quad g''' = 0$$

$$\frac{\partial^2 \theta_i{}^*}{\partial \beta_i{}^2} = -2 \times \frac{\partial \alpha^*}{\partial \beta_i} \times \tau \times t_i + \frac{\partial^2 \alpha^*}{\partial \beta_i{}^2}(1 - \beta_i \times \tau) \times t_i < 0 \qquad iff \quad g''' = 0$$

$$\frac{\partial^2 r_1}{\partial \beta_1{}^2} = \left[B \times \frac{\partial^2 \theta_1}{\partial \beta_1{}^2} - d''(\beta_1)\right] < 0 \quad iff \quad g''' = 0$$

$$\frac{\partial^2 r_1}{\partial t_1{}^2} = \left[B \times \frac{\partial^2 \theta_1}{\partial t_1{}^2}\right] < 0 \quad iff \quad g''' = 0$$

$$\frac{\partial^2 g_i}{\partial t_i{}^2} = -\frac{\partial^2 \alpha^*}{\partial t_i{}^2}(1 - \beta_i \times \tau) \times t_i - \frac{\partial \alpha^*}{\partial t_i}(1 - \beta_i \times \tau) > 0$$

$$\frac{\partial^2 g_i}{\partial \beta_i{}^2} = -\frac{\partial^2 \alpha^*}{\partial \beta_i{}^2}(1 - \beta_i \times \tau) \times t_i + \frac{\partial \alpha^*}{\partial \beta_i} \times \tau \times t_i > 0$$

$$\left[\frac{\partial^2 \theta_i{}^*}{\partial t_i{}^2} + \frac{\partial^2 g_i}{\partial t_i{}^2}\right] = \frac{\partial \alpha^*}{\partial t_i} \times (1 - \beta_i \times \tau) < 0$$

$$\left[\frac{\partial^2 \theta_i{}^*}{\partial \beta_i{}^2} + \frac{\partial^2 g_i}{\partial \beta_i{}^2}\right] = -\frac{\partial \alpha^*}{\partial \beta_i} \times \tau \times t_i < 0$$

$$\frac{\partial^2 n_1}{\partial \beta_1{}^2} = -\frac{B \times \left[\frac{\partial^2 \theta_2}{\partial \beta_1{}^2} + \frac{\partial^2 g_2}{\partial \beta_1{}^2}\right]}{2a} > 0$$

$$\frac{\partial^2 n_1}{\partial t_1{}^2} = -\frac{B \times \left[\frac{\partial^2 \theta_2}{\partial t_1{}^2} + \frac{\partial^2 g_2}{\partial t_1{}^2}\right]}{2a} > 0$$

$$\frac{\partial^2 n_1}{\partial \beta_1 \partial t_1} = -\frac{B}{2a} \times \left[\frac{\partial^2 \theta_i{}^*}{\partial \beta_i \partial t_i} + \frac{\partial^2 g_i}{\partial \beta_i \partial t_i}\right] = -\frac{B}{2a} \times \left((1 - \alpha^*) \times \tau - \frac{\partial \alpha^*}{\partial t_i} \times \tau \times t_i\right) < 0$$

$$\frac{\partial^2 r_1}{\partial \beta_1 \partial t_1} = \left[B \times \frac{\partial^2 \theta_1}{\partial \beta_1 \partial t_1}\right] > 0$$

$$\frac{\partial^2 n_1}{\partial t_1 \partial \beta_1} = -\frac{B}{2a} \times \left[\frac{\partial^2 \theta_i{}^*}{\partial t_i \partial \beta_i} + \frac{\partial^2 g_i}{\partial t_i \partial \beta_i}\right] = -\frac{B}{2a} \times \left(\frac{\partial \alpha^*}{\partial \beta_i} \times (1 - \beta_i \times \tau) + (1 - \alpha^*) \times \tau\right) < 0$$

$$\frac{\partial^2 r_1}{\partial t_1 \partial \beta_1} = \left[B \times \frac{\partial^2 \theta_1}{\partial t_1 \partial \beta_1}\right] > 0$$

$$\frac{\partial r_1}{\partial \beta_2} = \frac{\partial^2 r_1}{\partial \beta_1 \partial \beta_2} = \frac{\partial^2 n_1}{\partial \beta_1 \partial \beta_2} = \frac{\partial^2 n_1}{\partial \beta_2 \partial \beta_1} = \frac{\partial r_1}{\partial t_2} = \frac{\partial^2 r_1}{\partial t_1 \partial t_2} = \frac{\partial^2 n_1}{\partial t_1 \partial t_2} = \frac{\partial^2 n_1}{\partial t_2 \partial t_1} = \frac{\partial^2 n_1}{\partial t_1 \partial \beta_2} = 0$$

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