Ecological fiscal incentives and spatial strategic interactions: the case of ICMS-E in Paraná

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Abstract

This paper investigates the efficiency of the ICMS *ecológico* (ICMS-E) by testing the presence of spatial interactions between Brazilian counties on their propensity to create CUs in the state of Paraná between 2000 and 2010. In 1992, Paraná has introduced a fiscal transfer from the state to municipalities, called the ICMS-E, as a payment for environmental services based on internal financing to (i) compensate counties subject to land use restrictions (set aside land for protection by the creation of conservation units (CUs)) and (ii) incite counties to increase the area (or improve the management) of land set aside for protection. The nature of the ICMS-E which (1) influences directly the land allocation rule-decision of counties and (2) is a part of a more broad fiscal transfer mechanism named the ICMS (rewards counties in function of the valued added created by each county) implies that municipalities have the choice between (1) set aside their land for protection and be awarded by the ICMS-E, and (2) convert their natural land to attract agricultural and industrial plants and be awarded by the ICMS. Moreover, the ICMS-E is a fixed pool of money implying possible strategic interactions between counties in their land allocation. From a land use model and a spatial Bayesian tobit model, our results suggests the presence of negative spatial interactions between counties. These negative spatial externalities can be explained by the hypothesis of profitability which states that the county will prefer to develop economic activities to attract peasants and firms of its neighbors which have preferred to create CUs. This result, explained by the functioning of the ICMS-E, questions finally the efficiency of a such mechanism. Although there were strong incentives for counties to create CUs in the first year of the implementation of the ICMS-E, the present study suggests that the efficiency of a such mechanism becomes questionable after several years of implementation by creating negative spatial interactions between counties.

Keywords: Spatial interactions, Fiscal federalism, Land use, Biodiversity, Brazil.

JEL codes: D73, Q23.

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1 Introduction

Development Policies implemented in Brazil from the late 60's to the mid 80's were considered as "very aggressive with little regard to the environment." However, the growing interest of the international community for environmental problems and the worsening of the economic situation in Brazil led to a change in this in the late 80's (Andersen et al., 2002). Indeed, several programs sprang up with the purpose of promoting sustainable development. This change was of the utmost importance since Brazil is recognized as a major reserve of forests and biodiversity. Myers et al. (2000) point out that Brazil is estimated to host one-sixth of the endemic plant species of the Earth, to cite but just one example.

Among the programs developed to promote sustainable development, the ICMS-Ecologico or ICMS-E ("*Imposto sobre Circulacão de Mercadorias e Servicos - ecológico*" or "*Ecological value added tax*") is of particular interest. It is a fiscal transfer mechanism implemented in order to promote land conservation at the local level. It is not only designed for Amazonian states[1] but also aims at protecting Atlantic forests, threatened by fragmentation (see Brooks and Balmford (1996), Brooks et al. (1999) or Pütz et al. (2011) for example).

The ICMS-E is an intergovernmental fiscal transfer from state to municipalities, used today in about half of the Brazilian states. It rewards municipalities for the creation of protected areas (namely conservation units, CUs) and watershed reserves. One reason for its implementation was the demand from municipalities hosting federal or state managed protected areas to be compensated for the opportunity cost of providing this public good. Yet it also aims to act as an incentive to create new protected areas.

Since its implementation in the early 90's, the ICMS-E is a real success in terms of CUs creation. In 2000, the areas under protection had already increased by 62.4% in the State of Minas Gerais and by 165% in the State of Paraná (May et al., 2002). Moreover, the mechanism has two interesting features. It is implemented (1) without external source of financing (the funds redistributed are collected from goods and services tax in the concerned State), and (2) at very low transaction costs. This way, it has been claimed that the ICMS-E could be an alternative to other instruments such as pollution permits or pigovian taxes, notably for the implementation of commitments in international environmental agreements (see Farley et al. (2010)).

Despite attractiveness, very few studies have been carried out on the ICMS-E. Grieg-Gran (2000) analyzes which municipalities are better off with the ICMS-E reform. She finds mixed evidence. She points out that until 2000, only 60% of the municipalities of Rondonia and Minas Gerais with protected areas benefited from the introduction of the ICMS-Ecologico. Furthermore, May et al. (2002) provide some interesting State level statistics for the Paraná and Minas Gerais states as well as several inspiring case studies[2]. Finally, Ring (2008) highlights the appeal of the ICMS-E by providing a clear description of the mechanism along with trend and macro level statistics on the creation of CUs in the three states mentioned above.

However, although these three studies are informative and highlight the strengths of the ICMS-E,

[1] Such as *Avanca Brasil* for example (Andersen et al., 2002).

[2] They interviewed several mayors, asking them why they used the ICMS-E mechanism.

no one questioned the efficiency of the mechanism. Yet, the ICMS-E is a decentralized policy, and as stated by Oates and Portney (2003), the efficiency of a decentralized policy implies the absence of interactions between agents. However, as we will see in our theoretical part, there are several reasons for expecting municipalities to influence each other when deciding to create CUs or not and that there is a risk of a race to the bottom, i.e., competition between counties[3] to attract economic agents which leads to the setting-up of lax environmental standards.

Therefore, the aim of this chapter is to investigate whether or not there are interactions between municipalities when they set the propensity of their lands under protection. We collected data on the ICMS-E for 399 municipalities of the state of Paraná from 2000 to 2010. This state constitutes therefore a case of primary interest because it was the first to adopt the considered mechanism in 1991 and a pioneer by introducing a quality-weighting factor for the redistribution of the ICMS-E.

The contributions of this paper are diverse. We build a new database thanks to the reports released by the IAP (Instituto Ambiental do Paraná). We adapt a land-use model from Chomitz and Gray (1996) to the problematic of setting aside lands for protection and assess its validity through the bayesian spatial tobit estimator proposed by LeSage (1999) and LeSage and Pace (2009). The spatial Bayesian tobit model allows us to test the presence of interactions between municipalities in their conservation decisions. Negative spatial interactions between municipalities are found, suggesting that the profitability hypothesis applies and that conservation behavior are strategic substitutes.

The chapter is organized as follows. Section 2 provides a review of literature and places our paper at the frontier of the literature on i) the provision of public goods, ii) the environmental federalism and iii) the land use motivations. Section 2 also explains how our paper differs from previous works on the ICMS-E. Section 3 discusses the context in which the ICMS-E was implemented in the Brazilian state of Paraná. Section 4 presents the theoretical land use model and estimation strategy while Section 5 gives the results. Section 6 concludes with possible policy implications.

2 Literature review

The aim of this chapter is to analyse the efficiency of ICMS-E on the land allocation decision rule at county level through the presence of spatial strategic interactions. The aim (promote the production of local public good), the nature (fiscal transfer scheme) and the functioning (based on a fixed pool of money) of the ICMS-E allows this paper to be placed in the three strands of the literature: the provision of public good, the fiscal federalism and the land use competition model.

First, the main goal of the ICMS-E is to provide a public good, here the conservation of biodiversity. Thereby, the ICMS-E is an incentive tool used to incite local actors, here the counties, to take into account the positive externalities of preserving biodiversity by paying them to do so. The literature on the provision of public goods is substantial but here we focus only on studies concerning the incentives at local level through payments in the case of biodiversity. The loss of biodiversity as well as the lessening of the environmental services provided by ecosystems for human well-being have been recognized as one of the main global problems. Biodiversity calls for centralised policies and standard setting such as numerous international conventions like the Convention on Biological Diversity (WRI,

[3] The terms county and municipalities will be used indistinctively in the rest of the paper.

2005). However, the state of the biodiversity is mainly influenced by decentralised activities, despite global centralised standards. Also, it is widely recognized that the improvement of the value of ecological services through market prices is even more difficult since there are fundamental conflicts between the rules by which markets allocate resources and the rules which govern ecosystems (Gowdy, 1997). For instance, this is especially the case for benefits related to non-use values which are difficult to assess trough market prices, such as existence and option values. This way, some papers address the problem to conciliate the local and global level. For instance, Horton et al. (2003) use a contingent valuation to elicit individuals' preferences for non-market environmental resources such as the payment for the implementation of a proposed programme of protected areas in Brazilian Amazonia. Their study shows large-scale positive spillovers of the preservation of the Brazilian forest since the majority of households in Italy and the UK were willing to pay to support large-scale tropical forest preservation efforts. List et al. (2002) analyze the "beggar thy neighbour" effect in the case of U.S. environmental policy making at state-level concerning endangered species expenditure patterns. They show that states free ride in the sense that they spend less relative to federal government in the protection of endangered species. Relating to this, some authors have tried to conciliate the global and local level by designing an optimal pattern of biodiversity protection which reflects both the local and global benefit of biodiversity protection (Perrings and Gadgil, 2003). One such patterns creates incentives to reward or pay local communities for their conservation efforts as does the ICMS-E (Ring, 2008). This solution calls for a fiscal federalism which is the second strand of literature to which our paper belongs.

Second, the ICMS-E is a fiscal redistribution from the state to municipalities based on environmental federalism which studies the role of spatial externalities in the choice of the level of government in the provision of the public good. The mechanisms underlying the ICMS-E allow for the analysis of the interrelationships between municipalities and the efficiency of decentralisation. The literature on fiscal federalism is also substantial but we focus mainly on papers concerning environmental federalism with important spatial externalities such as the ICMS-E. Basically, environmental fiscal federalism is a sub-field of fiscal federalism literature which is linked to public economics[4]. Fiscal federalism typically occurs in the context of a system with several levels of government and uses a general normative framework for the estimation of functions to different levels of government and the appropriate fiscal instruments for carrying out these functions (Oates, 1999). In the case of environmental fiscal federalism, this implies the substantial "issue of the appropriate role of the various governments in the setting of environmental standards, the design of regulatory measures to attain the standards, and the monitoring and enforcement of these measures" (Oates, 2001, p.3). Regarding this setting, the principle of fiscal decentralisation has been first advanced by (Oates, 1972). The main idea is that most public goods and services could be provided more efficiently at the lowest governmental level if production and consumption are limited[5]. Moreover, this rule of decentralisation for allocating public goods and services should apply only in the case of none economies of scale, otherwise the provision of the public goods should be moved to the cost-efficient centralised level. However, since local public

[4]See Oates (1999) for a review of fiscal federalism.

[5]Decentralization is also viewed as a way for responding more appropriately to the regionally differing preferences of the population (see for instance Oates (2001)).

good has the use property of non-rivalry and non-excludability, the presence of spatial externalities or spillovers can occur between jurisdictions (see Ring (2008) for a review of the literature on this point). In this case, third mechanisms have been advanced to internalise these spatial spillovers. One solution advanced is to internalise spillovers through fiscal transfers from more centralised levels to the local level to compensate for the external benefits of its expenditures to produce the local public good (Olson, 1969)[6]. Beyond this problem of the allocation of the local public good through decentralisation and the internalisation of spatial spillovers, the problem of the "race-to-the-bottom" has been widely studied in the literature (Oates and Portney, 2003). The basic idea is that "local" officials could set excessively lax environmental standards to hold down the costs associated with the preservation of the environment for existing and prospective firms with the aim of encouraging new business investment and economic growth. In the literature, many papers focus on these strategic interactions between jurisdictions in the provision of public good such as biodiversity conservation. There is both an extensive theoretical literature (see Wilson (1996) for a global review of this literature and Oates and Portney (2003) for a review in the case of environmental public goods) and empirical studies on biodiversity (see for instance Levinson (1999); List and Gerking (2000); Fredriksson and Millimet (2002) for the case of United States, Murdoch et al. (1997) for the European Union, and Akin et al. (2005); Arze et al. (2008); Rota-Graziosi et al. (2010) for developing countries in the case of public spending, since no paper studies the issue of "the race-to-the-bottom" for biodiversity conservation in developing countries).

Thirdly, the ICMS-E implies that counties have to choose between the preservation of the natural areas and their conversion into other economic uses such as agriculture. In turn, the ICMS-E influences the allocation of land, i.e., land uses, at the county level (see Kaimowitz and Angelsen (1998) for a review of models used to study deforestation and Nelson and Geoghegan (2002) for a review of the literature concerning the land use based deforestation model). The literature on land use is also substantial but we focus only on studies concerning deforestation at local level. This literature studies the role of economic factors inducing deforestation and thereby threatening biodiversity, giving particular attention to the exploitation pattern of forest resources. Chomitz and Gray (1996) are the first to use this type of spatially explicit model to study the effect of road development on deforestation in Belize. Then, many papers apply this model to a pixel or household levels (for instance Chomitz and Thomas (2003); Marchand (2010) for Brazil; Deininger and Minten (2002); Alix-Garcia et al. (2005); Alix-Garcia (2007) for Mexico; Godoy and Contreras (2001) for Bolivia; Godoy et al. (1997) for Honduras; and Cropper et al. (2001) for Thailand) or to an entire municipality (for instance Pfaff (1999); Araujo et al. (2009) for Brazil, Deininger and Minten (1999) for Mexico).

Finally, this chapter, being in this three strands of the literature, differs from the other (few) papers which have studied the ICMS-E. The existing empirical studies are based on the States of Paraná, Minas Gerais and Rondonia, which were among the first States to introduce the ICMS-E, and focus more on the effects of the ICMS-E in terms of total areas protected. For instance, Grieg-Gran (2000) examines the effects of the ICMS-E in the states of Minas Gerais and Rondonia and finds

[6]The two other solutions are: the principle of fiscal equivalence and the regional cooperation. The first solution proposed by Olson (1969) consists in having a match between those who receive the benefits of a collective good and those who pay for it. The second solution relies on negotiations between the relevant parties to achieve an efficient Coasian type of resolution of jurisdictional spillovers (Oates, 2001).

that both the compensation and incentive objectives have been achieved in the two States. She also studies the distributional impact of the ICMS-E and finds that in the state of Rondonia this effect is difficult to observe whereas in Minas Gerais, the ICMS-E has more adversely affected the wealthiest counties. May et al. (2002) provide a presentation of how the ICMS-E functions. They actually tries to understand how and under what conditions the ICMS-E works. They find that the ICMS-E has promoted the conservation of natural resources by increasing both the size and the number of protected areas. For instance, the area of municipal protected parks has increased respectively by 192 and 236 percent between 1991 and 2000 in the state of Paraná and Minas Gerais. Ring (2008) analyses the effectiveness of the ICMS-E through the creation of new protected areas. She also finds that municipalities in the state of Paraná and Minas Gerais developed a strong interest in designating new public protected areas at the local level. Finally, all of these papers conclude that the Brazilian experience illustrates that the ICMS-E is efficient both to compensate for land-use restrictions and incite to engage in more conservation activities at the local level.

In turn, this chapter is linked to the previously cited literature but differs by studying the efficiency of the ICMS-E through the presence of interactions between counties in their land allocation.

3 ICMS-E and conservation units in Paraná

3.1 Presentation of the ICMS-E

Brazil is a federal country with 27 states which capture most of their revenue from tax on the circulation of goods and services, i.e., a value-added tax (VAT), named the ICMS tax (*Imposto sobre Circulacão de Mercadorias e Servicos*). They have to return 25% of their revenue collected from sales taxes to municipalities following certain criteria. Three quarters of this redistribution is defined by the federal constitution (the main criterion is the added value created by each municipality), but the Article 158 of the Federal Constitution states that the remaining 25% (i.e., 6.75% of the total) is allocated according to each state's legislation (for instance based on population, geographical area and primary production).

In 1992, the state of Paraná was the first to reward municipalities for protected areas (biodiversity) and watershed reserves (water quality) within their boundaries by redistributing the ICMS-E according to environmental criteria (see May et al. (2002, P.175) for a more complete presentation of the law making process in Paraná.)[7]. It is worthy noticing that municipalities have no obligation to create and improve protected areas, but are simply rewarded depending on the extent to which they meet the criteria in comparison with other municipalities. Also, since only a fixed pool of money is available in any given year, the municipalities compete with each other to receive the money.

This new fiscal incentive tool was called ICMS-E or "ecological ICMS". In Paraná, the law implemented awarded 5% of ICMS revenue to municipalities in proportion to their protection of watersheds and conservation areas (also called "conservation units" (CUs)). Half of this (2.5%) is used to re-

[7]14 other Brazilian states have already introduced the ICMS-E, including São Paulo (1996), Minas Gerais (1996), Rondonia (1996), Amapá (1996), Rio Grande do Sul (1998), Mato Grosso (2001), Mato Grosso do Sul (2001), Pernambuco (2001), Tocantins (2002) (see the official website of the ICMS-E, http://www.icmsecologico.org.br/, and Veríssimo et al. (2002); Ring (2008)).

ward municipalities for the creation of CUs. The Biodiversity Conservation Coefficient, used for the redistribution of the ICMS-E between counties, is derived from the ratio of CUs on total area. These CUs can be publicly managed (federal, state or municipal level), privately owned or managed by public-private partnerships (such as *reserva particular do patrimônio natural*, RPPN). Payments to municipalities are also provided for federal and private protected areas. Also, the protected areas may be used directly (for instance sustainably managed forest and indigenous areas) or indirectly (for instance parks, biological reserves or ecological stations). The other half is for those municipalities that have watershed protection areas which partly or completely provide services for public drinking water systems in neighboring municipalities[8]. The main motivation of this fiscal redistribution policy was initially to compensate municipalities for the opportunity costs of conservation areas (often decided by the central level, i.e., the state) and for protecting watersheds. But this policy created significant incentives for the creation of new protected areas which, in turn, allow to increase the number and area of both state and municipal protected areas.

Moreover beyond the quantitative aim of this policy, Paraná was the first to insert qualitative criteria into the ICMS-E (Farley et al., 2010; May et al., 2002). This reflects improvements over time in qualitative features of CUs and also their relationship with the surrounding community[9]. The more these objectives are fulfilled by municipalities, the more the revenue of ICMS-E received are substantial. Basically, the state of Paraná use two components to calculate the Biodiversity Conservation Coefficient: a quantitative component and a qualitative one. The former is the percentage of municipal land area under conservation units corrected by a value describing the level of restriction on use such as biological reserve. The latter is a qualitative criteria that evaluates the quality of the conservation unit on the basis of variables such as the biological and physical quality, the quality of water resources in and around the CUs, how important the CU is in the regional ecosystem, the quality of planning, implementation, maintenance and the legitimacy of the unit in the community. The quality of each CU is assessed by regional officers of the state Environmental Institute of Paraná (Instituto Ambiental do Paraná, IAP). Their evaluation is then expressed as a score called quality factor used in the calculation of revenue distribution. Each score differs in accordance with the type of CU as well as the objectives of state environmental policy, giving greater weight to the state's environmental management capacity over that of municipal or federal agencies[10].

To determine the additional funds allocated to each municipality, the biodiversity conservation coefficient or ecological index EI_i of the municipality i is calculated as follows (this part is adapted from Loureiro et al. (2008, p.22-23) and Ring (2008)).

First is the calculation of the conservation coefficient (BCC_{ji}) of each CU j in the municipality i

[8]See for instance the case of the municipality of Piraquara which have 10% of its territory covered by protected areas for biodiversity conservation and the remaining 90% used for conserving a major watershed to supply the Curitiba metropolitan region (1.5 million inhabitants) with drinking water (May et al., 2002; Ring, 2008).

[9]For instance, the quality criteria of a CUs will increase if the county creates buffer zones around this area.

[10]The quality index is also assessed by exceeding compliance with extant agreements with municipalities; development of facilities; supplementary analysis of municipal actions regarding housing and urban planning, agriculture, health, and sanitation; support to producers and local communities; and the number and amount of environmental penalties applied, within the municipality, by public authorities (May et al., 2002).

as follows:

$$BCC_{ij} = \left(\frac{Area\ CU_j}{Area\ municipality_i}\right) * FC_n, \tag{1}$$

where $Area\ CU_j$ and $Area\ municipality_i$ are respectively the area of the conservation unit j and the area of the municipality i. Each BCC_{ij} is multiplied by a conservation factor FC_n which is variable and assigned to protected areas in according to management category n (see the table 1 page 23 in appendix for more information of the weighting factor of each protected areas).

Then each BCC_{ij} is assigned an ESC criterion to take into account the variation of the quality as follows:

$$BCCQ_{ij} = [BCC_{ij} + (BCC_{ij} * ESC)], \tag{2}$$

where ESC is the variation of the quality of the CU weighted by the management strategy and the nature of the protected areas, i.e., municipal, state, federal.

Then the municipal conservation factor (MCF_i) is based on the sum of each $BCCQ_{ij}$ in the municipality i as follows:

$$MCF_i = \sum_{j=1}^{J} BCCQ_{ij}. \tag{3}$$

where J is the number of CU in the municipality i[11]. Finally the biodiversity conservation coefficient or ecological index EC_i of the municipality i is

$$EI_i = \frac{MCF_i}{SCF}, \tag{4}$$

where the state conservation factor SCF is given by the sum of all municipal conservation factors (MCF) in the state:

$$SCF = \sum_{i=1}^{Z} MCF_i, \tag{5}$$

where the Z the number of municipalities in the state which receives funds from the ICMS-E.

A brief overview of the evolution of the number of counties into the ICMS-E for municipal CUs between 2000 and 2010 is given by the figure 3 (in appendix, page 40). The number of municipalities which have received funds from the ICMS-E has increased of 9 counties between 2000 and 2010 (57 in 2000 against 66 in 2010) over the 399 counties in the dataset. In consequence, respectively 342 and 329 counties did not received fiscal transfer from the ICMS-E for the creation of municipal CUs in 2000 and 2010. Moreover, it is worth notice that 4 counties had no longer received funds from the ICMS-E, i.e., they converted municipal CUs, during the last decade while 13 new counties received funds from ICMS-E for the creation of their first municipal CUs.

In a broader view, there were 174 counties into the ICMS-E in 2000 against 192 in 2010, i.e.,

[11] For instance, Curitiba has 15 conservation units in 2000.

receiving funds to compensate the presence of any CUs in their territory (see figure 4, page 41 in appendix). The number of counties into the fiscal mechanism has thus increased while 4 counties have decided to go out of the mechanism. In contrast, 22 new counties have earned money from the ICMS-E.

3.2 Evolution of conservation units in Paraná

The ICMS-E mechanism has been first implemented in 1992. From this date up to 2010, the evolution of the CUs created in the state of Paraná is a way to test the success of the ICMS-E.

From data on CUs created between 1991 and 2000, collected in (May et al., 2002), and our data between 2000 and 2010, the figure 2 gives the evolution of the area of all CUs in hectare between 1991 and the last year of available data in 2010. It is found that the evolution of CUs can be divided into two periods. In the first decade, the creation of CUs has sharply increased suggesting that the ICMS-E has not only compensate counties for the creation of CUs but also incite them to create CUs. However, in the last decade (from 2000), the creation of CUs is found to hold steady with a very low increase of 5 percent. From this can be assumed that the level of created CUs in the state of Paraná through the ICMS-E mechanism has reach its equilibrium.

However, these figures concerns all CUs, i.e., federal, state and municipal CUs. The evolution of created municipal CUs is relevant in our study which concerns the implication of the ICMS-E in terms of spatial strategic interactions on the creation of municipal CUs. From our data between 2000-2010, it is found that the evolution of the number of municipal CUs follows the same trend than all CUs. In consequence, our data seem to confirm that from 2000, the created dynamics by the ICMS-E have reach their equilibrium. This overview suggests that ICMS-E is no longer sufficient to incite counties to create CUs after several years of implementation.

4 Conceptual framework

In order to analyse the influence on the propensity of a county to create parks of its neighbors, an economic land use model is used (Chomitz and Gray, 1996; Pfaff, 1999; Chomitz and Thomas, 2001; Arcand et al., 2008). The starting point is the dual nature of the model implying simple assumption that each land is allocated between alternative uses to maximise returns. In this model, the profitability of each use is compared to implement the decision concerning the land allocation. From this model, a county-level, land-allocation decision rule is derived which provides an econometric deforestation equation to be estimated.

4.1 Basic land-use model

Following Chomitz and Gray (1996) and Pfaff (1999), we assume that a county can choose their land allocation from a binary framework. It is assumed that the county can be defined as an economic agent which could decide the land use allocation of each of its plots. This way, this model differs from an aggregated plot-level decision rule model into a county-level model (Pfaff, 1999). We can made this assumption since we observe only the creation of municipal conservation units (CUs), i.e., a county-level decision.

At any point in time, a county will decide to allocate a plot of land between different land uses to maximize profit:

$$\max \pi^l_{ij} = P^l_{ij} Q^l_{ij}(I^l_{ij}) - R^l_{ij} I^l_{ij}, \tag{6}$$

where π^l_{ij} is the profit of the parcel i in the county j of a given land use l, P^l_{ij} are plot-level prices for the vector of feasible outputs from the given land use l, Q^l_{ij} is the vector of all outputs produced from the land use l, I^l_{ij} is the vector of inputs used in all types of production from the land use l, and R^l_{ij} are plot-level prices for the vector of inputs used.

Given the dual nature of the model, there are two possible land uses (protected, i.e., the creation of a municipal CUs, or unprotected, i.e., the conversion of a forested land). Optimal input choice yields to maximise π^l_{ij} and the county level decision rule regarding land use allocation is

$$\max_l V^l_{ij}, \tag{7}$$

where

$$\max_l V^l_{ij} = \max_{l|I} \pi^l_{ijt}. \tag{8}$$

Thus, the county decision concerns the choice of the land use to have the maximum profit from its land use. Put differently, the clearing decision will be in a static view: $Choose^l_{ij} = protected \quad$ if: $V^{protected}_{ij} > V^{unprotected}_{ij}$.

The municipality j will decide to preserve its plot i, i.e., create a CUs, only if the maximum profit generated from the conservation is higher that the maximum profit resulted from the conversion option.

This decision-rule based on the comparison of the maximum profit of each land use depends obviously on the prices of both inputs and outputs used in each land use. For instance, a decreasing price of the input used in the land use option *unprotected* leads to an increase of the profit associated with this land use. In this case, the county will be relatively better off if she decides to convert its natural land. Thereby, prices by influencing the magnitude of each profit have an impact on the decision rule which can be model as follows:

$$Choose^l_{ij} = protected \qquad \text{if } D^{protected}_{ij}(P^l_{ij}, R^l_{ij}) > 0,$$

where

$$D^{protected}_{ij}(P^l_{ij}, R^l_{ij}) = V^{protected}_{ij}(.) - V^{unprotected}_{ij}(.).$$

This representation of the land allocation decision-rule allows of integrating economic factors in the explanation of land use through their links with both input and output prices.

4.2 Observed variables and spatial interactions

4.2.1 Observed economic factors

The land use decision-rule is thus determined by $P^l_{i,j}$ and $R^l_{i,j}$ which are plot-level output and input prices. Put differently, this is the differential between prices of each land use option which will determine the land allocation. However, we cannot observe them directly so that we use closed county-level variables. Thus, the solution will be to use proximate variables which affect the differential prices and so in turn the land allocation decision. In the case of P_{ij}, the best way to approximate output prices at plot-level will be to have them at county-level P_j. Unfortunately, we have none of these variables so that local output demand variables are used such as the county population pop_j (as a scale measure of the potential local market for cleared economic activities), the share of industry in the total county's activities ind_j (as a measure of development projects), the share of agricultural activities in the total county's activities agr_j (as a measure of local agricultural food demand) and the income level in a county inc_j as a measure of the economic development. All of these variables are assumed to have an impact of the differential output prices in favor an increase of the *unprotected* option. Moreover, the effect of the variable *income* (per capita) could be more ambiguous since richer counties could be better of to preserve their forests for ornamental purposes. To test this idea, the quadratic term of *income* will be used. Thus, (1) poorer counties are assumed to be more incline to do parks since their comparative advantages to proceed in *unprotected* activities are lower than richer counties, and (2) richer counties are also assumed to create more parks. The quadratic term $incsq_j$ is thus assumed to be negative, i.e., the income effect on the creation of parks is concave.

In the case, of $R_{i,j}$, local input supply variables are used such as the rural density (per km^2) rur_j (as a measure of the rural wage) and the urban density (per km^2) urb_j (as a measure of the urban wage). These two variables are found to be proxies variables impacting the differential input prices in favor of *unprotected* activities. Put differently, these variables have a negative effect of the propensity to create parks by strengthening the opportunity cost of the *protected* option.

Lastly, we assume that the area of other CUS (federal and state), named FED_j could have an impact on the land allocation decision-rule through the differential prices. Given that the area of a county is by definition fixed, more non-municipal CUs increases the scarcity of the land. In this context, the effect of the land allocation decision is ambiguous. Assume that the land scarcity increases the land price. This pushes economic agent to not invest in this county since the cost for *unprotected* option goes up. The municipality knowing that can decide to protect the land and create a CUs to earn money from the ICMS-E. Alternatively, an increase of the land price can attract only the more efficient agents into the county pushing this latter to convert their forested land into potential productive land for agriculture and industry.

4.2.2 Spatial interactions

The aim of this work is to test for the presence of neighboring effects in the decision to create municipal CUs in a county. This issue is particularly relevant since the ICMS-E is a decentralized system, and as Oates and Portney (2003) state, one condition for the decentralization to be optimal is the absence of interactions between agents. Testing the presence of interactions is therefore crucial to assess the efficiency of the mechanism.

The interactions between a county and its neighbors can evolve in two directions. On the one hand, the level of CUs in a county and the one of its neighbors could be strategic complements. Indeed by decreasing its conservation index, the municipality offers firms and peasants an easier climate to make profits and to extend their activities. Moreover, a new firm could vote with its feet (Tiebout, 1956) and choose the municipality where the environmental standards are lower to settle down. This way, a race to the bottom could be observed[12].

On the other hand, if we think in terms of profitability of the two options, conservation and exploitation, we could expect conservation decisions to be strategic substitutes. The creation of new CUs by a county could have two effects. Firstly, since municipalities compete for a fixed pool of money, when a given municipality creates new CUs, it decreases the amount transferred by the state for each CUs, thus decreasing the profitability of the conservation option. Secondly, the creation of new CUs decreases the stock of lands available for economic production in a particular area. Then, it increases the value of plots available for economic production and then the profitability of the exploitation option. A municipality could therefore decide to increase its supply of land for economic agents (by decreasing its number of CUs), in order to attract peasants and firms when its neighbor is decreasing its. We could therefore expect protection decisions to be strategic substitutes.

From our theoretical framework, the land-allocation decision-rule for the plot i in the county j becomes

$$D_{ij}^{uncleared}(Q_k^{protected}, FED_j, pop_j, ind_j, agr_j, inc_j, incsq_j, urb_j, rur_j). \tag{9}$$

where $Q_k^{protected}$ is the level of CUs in the neighboring county k which is assumed to influence negatively $D_{ij}^{protected}$ by decreasing the profitability of the *protected* option and increasing the profitability of the exploitation (*unprotected*) option.

A land use decision-rule such as equation 9 leads to the equation which will be estimated and presented in the following subsection 4.3.

4.3 Econometric model and data used

To estimate the presence of interactions between municipalities in their conservation decisions, we borrow the methodology used in the tax-competition and public spending literature (see for example Case et al. (1993), Brueckner (2003), Lockwood and Migali (2009) or Rota-Graziosi et al. (2010)). We estimate a Spatial AutoRegressive (SAR) model, where the spatially lagged endogenous variable is a weighted sum of neighbors' decisions, such as:

$$P^* = \rho W P^* + \beta X + \epsilon \tag{10}$$

where P^* is a $N \times 1$ vector of the propensity to create a municipal CUs by a county. N is the number of municipalities in the sample, here 399. X is a $M \times N$ matrix of our M explanatory variables influencing the differential potential profit between land use conversion and land conservation previ-

[12] In practice, there is no mean to distinguish between a race to the top and a race to the bottom, but only to find strategic complementarity between decisions. However, our theoretical analysis lead us to think that if decisions are effectively strategic complements, it will lead to a race to the bottom.

ously defined (pop, ind, agr, inc, $incsq$, rur, urb and FED) and the β a vector of their corresponding coefficients. ϵ is a $N \times 1$ vector of residuals. WP^* is a spatially lagged endogenous variable, where W is a $N \times N$ contiguity matrix of which each element w_{jk} takes the value of 1 if two counties share a common border, 0 otherwise (where j identifies a municipality different from municipality k). Hence, ρ capture the presence of interactions between municipalities.

The dependent variable is latent, i.e., cannot be observed for $p^* < 0$. Indeed, there is a large number of zero observations in our sample. In 2010, 342 municipalities over 399 do not create municipal CUs. It is hard to think that each municipality is exactly in the same situation. We can therefore argue that censoring is at stake and that their is negative profits for the action measured by our dependent variable. Therefore, we have:

$$p_{j,t} = 0 \quad if \quad p^*_{j,t} \leq 0$$
$$p_{j,t} = p^*_{j,t} \quad otherwise,$$

where $p_{j,t}$ is the observed dependent variable. Following Chomitz and Gray (1996), we account for this censoring using a tobit model, where the conditional distribution of $p_{j,t}$ given all other parameters is a truncated normal distribution, constructed by truncating distribution from the left at 0.

Finally, the following expanded form of the spatial autoregressive tobit models is:

$$\begin{aligned} p^*_{j,t_{2010}} &= \rho \sum_{j \neq k}^{J} w_{jk} p^*_{k,t} + \beta p_{j,t_{2000}} + \delta FED_{j,t_{2010}} + \alpha_1 pop_j + \alpha_2 ind_j + \alpha_3 agr_j + \alpha_4 inc_j \\ &+ \alpha_5 incsq_j + \alpha_6 urb_j + \alpha_7 rur_j + \alpha_8 Curitiba + \mu_r + \vartheta_{i,t_{2010}}, \end{aligned} \tag{11}$$

where the observed dependent variable, $p_{j,t_{2010}}$, is alternatively (1) the ratio of municipal parks of county j in 2010 defined as the ratio between total CUs areas and total county area, and the coefficient of quality measuring the quality of the created municipal CUs (see subsection 3.1). This latter measure can be viewed as the propensity to create CUs since more efforts put into the maintain or the development of the quality of CUs implies for the county more money from the ICMS-E and thus less money from the ICMS which rewards counties on the basis of their created value added.

$p_{j,t_{2000}}$ represent the initial ratio or coefficient of quality in 2000. $FED_{j,t_{2010}}$ is the ratio of other CUs (federal and state CUs) in the county i in 2010. pop_j, urb_j and rur_j are respectively the average annual population growth, urban density and rural density between 2000-2010. ind_j (agr_j) is the average ratio between the GDP of industrial (agricultural) activities and the total municipal GDP between 2000 and 2008. inc_j is the annual average GDP per capita between 2000 and 2008 and $incsq_j$, its squared equivalent. $Curitiba$ is a dummy variable which takes a value of 1 for the capital of Paraná namely Curitiba and 0 otherwise to control for the strong differences of this county compared to the others. μ_r is a micro-region dummy representing a legally defined administrative areas consisting of groups of municipalities bordering urban areas. This dummy allows of controlling for unobserved fixed effects shared by same neighboring counties. In the state of Paraná, 40 micro-regions are censused for 399 counties.

Data concerning CUs ($p_{j,t_{2010}}$, $p_{j,t_{2000}}$ and $FED_{j,t_{2010}}$) are taken from the ICMS-E official website[13]. All other variables come from the IPEA DATABASE[14] (see table 2 page 26 in appendix for more information on descriptive statistics).

4.4 Spatial estimation

4.5 Estimator

The estimation of parameters from spatial autoregressive tobit model represent a computational challenge and cannot be done via analytic methods, such as maximum likelihood. Therefore we rely on the bayesian approach developed by LeSage (1999), LeSage and Pace (2009) and applied by Autant-Bernard and LeSage (2011).

In this approach, the unobserved negative profits associated to the censored 0 observations are considered as parameters to estimate. The model is estimated via MCMC (Monte Carlo Markov Chain) estimation procedure. The procedure use the Geweke m-steps Gibbs sampler to produce draws from a multivariate truncated normal distribution in order to generate the unobserved negative utilities associated to the censored 0 observations[15] [16].

4.6 Interpretation of the coefficients estimated

Coefficients from a SAR model cannot be interpreted directly. Indeed there is an implicit form behind the model presented in equation 10. It can be rewrite as:

$$P^* - \rho W P^* = \beta X + \epsilon \tag{12}$$

$$P^*(I_N - \rho W) = \beta X + \epsilon \tag{13}$$

$$P^* = (I_N - \rho W)^{-1}\beta X + (I_N - \rho W)^{-1}\epsilon \tag{14}$$

As we can see from equation 14, $\frac{\partial p^*}{\partial x'} \neq \beta$, but $\frac{\partial p^*}{\partial x'} = (I_N - \rho W)^{-1}\beta$. This occurs because of the spillovers generated by the decisions of neighboring counties. To interpret the coefficients of a spatial model, the researcher has to calculate the direct impact of a variable, its indirect impact and the total impact (equal to the direct impact plus the indirect one). Indeed, a change on an explanatory variable in a particular region will affect the p^* value of this region (direct impact), but also the other regions

[13]Data downloadable on this website http://www.icmsecologico.org.br/.

[14]Data downloadable on this website http://www.ipeadata.gov.br/.

[15]The m-steps correspond to the number of draws. Following LeSage and Pace (2009), considering our sample size(N=399), we choose m=10 even if could be relatively computationally challenging.

[16]In addition, to produce estimates that will be robust in the presence of non-constant variance of disturbances (heteroscedasticity) and outliers, it is assumed that, in the development of the Gibbs sampler, the hyperparameter r that determines the extent to which the disturbances take on a leptokurtic character is stated at 4 as suggested by LeSage (1999)In a Bayesian regression model, the relative variance terms are assumed fixed but unknown parameters that need to be estimated. Bayesian methods rely on an informative prior for the these parameters. This prior distribution will take the form of an independent $\frac{\chi^2(r)}{r}$ distribution. This allows us to estimate the additional parameters related to the variance terms by adding the single parameter r to the estimation procedure. See LeSage (1999, p.99-100) for more information.

because of the spatial spillovers (the indirect impact). Computation details of this impacts are clearly described in (LeSage and Pace, 2009, p.33-39).

5 Results

5.1 Neighboring effects and created CUs

Results concerning the neighboring effects and other economic factors on the propensity to create CUs for a county are presented in tables 3 (page 27) and 4 (page 28). First is presented results with the ratio between the total area of municipal CUs and the total area of the county as dependent variable. The second table provides results with the coefficient quality as an alternative variable of the propensity to create CUs. In both regressions, the contiguity spatial weight matrix is used to represent the prior strength between two counties. Also, the gibbs sampler approach with 10 steps, for the computation of the vector of parameters which replaces the unobserved latent utility (here for $p^*_{j,t} < 0$), and 1,000 draws is used for the estimation of the spatial autoregressive tobit model. Moreover, in each table, is presented the total impact of each control variable as well as its direct and indirect ones.

In the table 3 where CUs ratio is used as dependent variable, negative spatial interactions between counties are found suggesting that a county is more inclined to create municipal CUs if their neighboring counties decrease the number of their CUs. This way, this result points out that the hypothesis of profitability, predicted by the theoretical model, seems to be at stake in the choice of create municipal CUs in the state of Paraná between 2000 and 2010. This way, in this period, it is more profitable for a county to earn money from the ICMS (awarded according to the created value added) and thus to convert its natural land for agricultural or industrial plants to attract peasants or firms of neighboring counties which have preferred to create CUs and be awarded by the ICMS-E. The functioning of the ICMS-E is an explanation of these behaviors since the pool of money is fixed in the ICMS-E leading a county to be not incited to enter into the mechanism and so be more inclined to convert its natural land. In a such county with neighbors having created CUs, the ICMS-E increases the opportunity cost to create CUs and the profit to convert land by attracting economic agents of neighbors which could be more inclined to migrate toward a county promoting economic plants. This result is linked with the descriptive statistics proposed before and could explained the stable trend in the creation of municipal CUs in the last decade after a strong upward trend in the first years of the implementation of the ICMS-E.

Concerning the other economic factors assuming to have an effect on the land allocation rule-decision of a county (through their effects on the differential profit between land uses option), the population variables have the expected negative coefficient but only the urban density has a significant effect. This result can suggest that urban counties are less inclined to promote municipal CUs due to the presence of a strong urban demand for foods or industrial products.

Moreover, the structure of the county's economy is found to be important to explain the propensity to create municipal CUs. In fact, more is important the share of agriculture or industry in the municipal activities, less will be the propensity to create municipal CUs. This result points out the role of economic activities in the propensity to create CUs. More developed counties in terms of agricultural or industrial activities can be more incited to continue to develop their activities to earn money from the ICMS which awards counties on the basis of their created valued added.

Moreover, the income effect is concave (the additive term is positive and the quadratic one negative) but not significant[17]. Also, the other CUs in the county are found to be not significant to explain the propensity to create CUs[18](while Curitiba is found to be positive and significant since the capital is one of the most advanced counties in terms of created CUs[19].

Besides, the Table 3 provides the estimated direct, indirect and total effects of each explanatory variables. Recall that direct impact can be interpreted as a marginal impact, the indirect one as a spatial spillover effect and total as a summary measure of the total impact associated with changes in each explanatory variable. All significant effects previously presented (for population growth and the weight of agriculture and industry) are found to be mainly direct effects since their indirect counter parts are non significant. Concerning these latter effects, it is found that none explanatory variables has a significant indirect effect. Despite that, some variables have the expected signs as the urban density or the industrial or agricultural ratio. For instance, more is the urban population in the neighboring counties, more is the propensity for a county to create CUs since the neighbors is expected to create less CUs due to its important urban density. The same result applies for the weight of the agricultural or industrial sector. Also, concerning the indirect effect, it is found that the previous level of created CUs (in 2000) of neighbors decreases the probability for a county to created CUs in 2010. This result is significant at 10 percent and confirms the negative spatial interaction which occurs between counties.

Table 4 presents results for the coefficient of quality as dependent variable. Negative spatial interactions between counties are also found. This result has a double interest. First it confirms the negative effects of neighboring counties on the propensity to create CUs for a county. Second it states that the underlying mechanism of ICMS-E is certainly an explanation of these negative spatial interactions. In fact, a county will be incited to increase its coefficient of quality in the attempt to strengthen its share in the ICMS-E and earn more money. Thus, if this county decides to reduce its quality because its neighbors have increased their one, the reason can be that the county decides strategically to promote economic activities against CUs in an attempt to attract peasants or firms of its neighbors which have decided to increase the quality of their CUs. This result confirms thus the profitability hypothesis and the efficiency problem of the ICMS-E which reduces the incentives to increase the quality of CUs due to the functioning of this mechanism.

Concerning the other economic factors, the negative effects of agricultural and industrial activities are still found suggesting that more developed counties are less sensitive to increase the quality of their CUs. The reasons can be that these counties prefer to spend money in the development of their activities instead of in the maintain and the promotion of their CUs. Finally, neither the population

[17]Results do not change without the quadratic term. The income effect remains positive but non significant, the effects of other control variables do not change as well as the significant negative spatial interactions between counties.

[18]In all regressions, the variable $OtherCUsratio2010$ ($Othercoeff.quality2010$) refers to the federal and state managed CUs (coefficient quality) within a county, i.e., the variable $FED_{j,t_{2010}}$ in the conceptual framework.

[19]This result validates the necessity to control for the specific case of Curitiba for which the behavior is not explained by the current specification. In fact, though Curitiba has a strong urban density as well as an important industrial activity, the level of created CUs is important. Other underlying mechanisms occur to explain these results. For instance, the proximity with the state government or the development of an important middle classes more sensitive to environmental purposes can explain the specificity of Curitiba. Above all, these elements can be explained by our model by increasing the profitability of the *preserved* option.

variables or the income variables have a significant effect. Concerning the indirect effects (spatial externalities), two variables have a significant effect. First is the negative initial level of quality (in 2000) suggesting that more was the initial level of neighbors, less will be the propensity for the county to increase the quality of its CUs. The second significant indirect impact is the positive effect of agriculture. Thus, more is the weight of agriculture in neighbors of a municipality, more is the propensity to create CUs in this county.

5.2 Robustness checks

The previous regressions are run with different number of m-steps ($m = 1$ or $m = 20$) of the Gibbs sampler process and different number of draws (n=10,000). Robustness test are made on the estimation procedure since the main computational challenge using a Bayesian framework is the state of some parameters such as the number of draws or the number of m-step in the computation of estimated negative utility for the censored observations of the dependant variable (LeSage and Pace, 2009).

The first robustness test on the number of step in the Gibbs sampler process is to test the convergence in the computed vector of parameters which replaces the unobserved latent utility (here for $p^*_{j,t} < 0$) (LeSage and Pace, 2009, p.287). The basic idea is to build up an adequate sample from the truncated multivariate normal distribution. Using a value of $m = 10$ is fairly standard in applied code used in Bayesian framework but for robustness a value of $m = 1$ and $m = 20$ is used.

The second test consists in increasing the number of draws and comparing the inferences based on a smaller set of draws (here n=1,000) to those resulting from a larger set of draws (here n=10,000) in order to evaluate the accuracy of the convergence. The basic assumption is that if the inferences are identical, then formal diagnostics on convergence tests may have been misleading (see (LeSage, 1999, p124-125) for more details) and the convergence can be assumed to be good.

Tables 5 (page 29) and 7 (page 31) provide results with the CUs ratio as dependent variable for respectively 1 and 20 steps of the Gibbs sampler process with 1,000 draws. The spatial interactions are still found to be negative and significant as well as the urban density, the agricultural ratio and the industrial one. The level of created CUs in 2000 is now found to have a significant and negative indirect effect suggesting the presence of negative neighboring effects on the propensity to create CUs. Also, urban density is now found to have a significant positive indirect effect. This reinforces the role of ruban density in the decision to create CUs. If the neighbor of a county has a strong urban density, the propensity to create CUs in this county will be stronger since this county could expect that its neighbor is not incline to create CUs. All other results do not change.

Tables 6 (page 30) and 8 (page 32) provide results with the coefficient of quality as dependent variable for respectively 1 and 20 steps of the Gibbs sampler process with 1,000 draws. The spatial interactions are still negative and significant as well as the agricultural ratio (the industrial ratio is no longer significant). The level of the coefficient of quality in 2000 is still found to have a significant and negative indirect effect validating the presence of negative neighboring effects on the propensity to create CUs. Also, the positive indirect impact of agriculture on the coefficient of quality remains significant. As in the regression with $m = 10$, none other variables have a significant indirect effect.

Finally, the number of draws are increased to n=10,000. Tables 9 (page 33), 11 (page 35) and 13 (page 37) present results with the CUs ratio as dependent variable for respectively 1, 10 and 20 steps of the Gibbs sampler process with 10,000 draws while Tables 10 (page 34), 12 (page 36) and 14 (page 38) concern the same regression with the coefficient quality as dependent variable. In all regressions, the spatial interactions are still found to be significantly negative. In the case of the CUs ratio, the urban density and the weight of agriculture and industry are still significant negative effects while for the quality, only the weight of agriculture is still significantly negative. Concerning indirect effects, the initial level of either the ratio of CUs or the coefficient of quality is still found to be negative and significant. Also, two indirect effects appears robust: the positive indirect impact of urban density on the CUs ratio and the positive indirect impact of agriculture on the coefficient of quality.

Finally, in all regression, Curitiba is found to have a positive propensity to create municipal CUs. To sum up, six results seems to be robust: (1) the negative spatial interactions, (2) the spatial externalities of the initial level of both the CUs ratio and the coefficient of quality, (3) the negative direct and positive indirect effect of agriculture on the coefficient of quality, (4) the negative direct and positive indirect effect of urban density on the CUs ratio, (5) the negative direct effect of agriculture and industry on the CUs ratio, and (6) Curitiba has a positive propensity to create municipal CUs and to increase the quality of its municipal CUs.

6 Conclusion

The aim of this chapter was to assess the efficiency and the functioning of the ICMS-E by testing the presence of spatial interactions between Brazilian counties in the state of Paraná. The ICMS-E is a fiscal tool developed in Brazilian states to promote the conservation of natural land by the creation of conservation units (CUs) in Brazilian counties. The ICMS-E is a fiscal transfer from the state to municipalities on the basis of the performance of each county in the creation and management of CUs. This way, ICMS-E can be viewed as a payment for environmental services based on internal financing.

This fiscal scheme is important since it is a way to finance PES but also it is a fiscal transfer in a federalism context. This nature gives strong hypothesis to test the efficiency of this fiscal scheme at the local level, i.e., into the horizontal relationships (between local government here counties). In fact, the questions of the efficiency of fiscal transfer mechanisms have been widely studied in literature and this analysis is an attempt to propose a new investigation through the role of spatial interactions between Brazilian counties, which can be created by ICMS-E, in the allocation of their land.

Indeed, the ICMS-E influences directly the land allocation rule-decision of counties. The ICMS-E is a part of a more broad fiscal transfer mechanism named the ICMS. This latter rewards counties in function of the valued added created by each county. Thus, municipalities have the choice between (1) set aside their land for protection and be awarded by the ICMS-E, and (2) convert their natural land to attract agricultural and industrial plants and be awarded by the ICMS.

Therefore, this study tries to investigate if the behavior of neighboring counties in terms of created municipal CUs has an effect on the propensity for a county to create municipal CUs between 2000 and 2010 in the state of Paraná. The choice of the time-span analysis is motivated by the availability of data but is interesting due to the fact that, in this period, the level of municipal created CUs is remained very stable after a strong upward trend in the first decade of the implementation of the

ICMS-E (1992-2000) suggesting a structural break. This way, the mechanism of ICMS-E seems to reach its equilibrium in terms of created CUs questioning its efficiency.

From a land use model and a spatial autoregressive Bayesian tobit model, the results suggests the presence of negative spatial interactions between counties. These negative spatial externalities can be explained by the hypothesis of profitability which states that the county will prefer to develop economic activities to attract peasants and firms of its neighbors which have preferred to create CUs. The functioning of the ICMS-E is an explanation of this result. Since the pool of money shared between counties is fixed, it is more preferable for a county to earn money from the ICMS by increasing its economic activities in the case where its neighbors have decided to create CUs and earn money from the ICMS-E.

The result do not exert a race to the bottom between counties which would have questioned finally the efficiency of the ICMS-E. However, the strategic substitutability nature of conservation behavior seems to lead the mechanism to reach an equilibrium. This is due to the fact that counties compete for a fixed pool of money. However, there is no reason that this fixed pool of money leads to the optimal level of land set aside for protection. This way, the efficiency of the ICMS-E can be questioned. Policy makers should take into account these potential evolutions of a such mechanism to avoid these negative externalities. Policy recommendations would be to increase the attractiveness of the mechanism by increasing the “piece of the pie”.

Lastly, the ICMS-E has had a great success and allowed to increase the number of CUs in Paraná. This experience should be viewed as a new and interesting tool to finance local public good from internal financing but by taking into account the potential negative spatial interactions.

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Paraná in Brazil

Calculation of the ICMS-E: the conservation factor

Table 1: Conservation factor FC_n for different management categories n of protected areas in Paraná

Management category	Federal	State	Municipal
Ecological research station	0.8	0.8	1
Biological reserve	0.8	0.8	1
Parks	0.7	0.7	0.9
Private natural heritage reserve (RPPN)	0.68	0.68	.
Area of relevant ecological interest	0.66	0.66	0.66
Forest	0.64	0.64	0.64
Indigenous area	0.45	.	.
Buffer zones (*Faxinais*)	.	0.45	.
Environmental protection area	0.08	0.08	0.08
Special, local areas of tourist interest	0.08	0.08	0.08

Source: Adapted from (Loureiro et al., 2008, p.73). A point (.) mentions that there is none CU of this nature. For instance, there is none municipal or state indigenous area.

Creation of CUs over time

Descriptive statistics

Table 2: Summary statistics

Variable	Mean	(Std. Dev.)	Min.	Max.	N
CUs ratio (2010)	0.0034	(0.0238)	0	0.2175	399
Coefficient quality (2010)	0.0018	(0.009)	0	0.1272	399
CUs ratio (2000)	0.0018	(0.0156)	0	0.1993	399
Coefficient quality (2000)	0.0013	(0.0093)	0	0.1695	399
CUs ratio (Federal, State) 2010	0.0444	(0.1322)	0	0.9876	399
Coefficient quality (Federal, State) 2010	0.0135	(0.0386)	0	0.3254	399
Population growth	2.2483	(11.7301)	-38.4769	73.3038	399
Ratio agriculture	0.3051	(0.1484)	0.0004	0.6235	399
Ratio industry	0.1439	(0.1148)	0.0288	0.8336	399
Log GDP	1.6361	(0.3994)	0.8232	3.7569	399
Log GDP squared	2.836	(1.5153)	0.6777	14.1145	399
Rural population density	9.4345	(10.9149)	0	192.9066	399
Urban population density	51.1113	(233.5605)	0.8544	3918.803	399

Source: Authors' calculation.

A Tables of results

A.1 Main results

Table 3: Spatial interactions and CUs ratio with 10 m-steps and 1,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.007011			
	0.039946			
CUs ratio 2000	2.450483	2.470317	-0.020291	2.450026
	0.000000	0.000000	0.102321	0.000000
Other CUs ratio 2010	-0.000710	0.001981	0.000026	-0.001753
	0.976757	0.946970	0.922559	0.947293
Pop. growth	-0.000322	-0.000327	0.000003	-0.000325
	0.259430	0.288006	0.415655	0.288136
Agricultural ratio	-0.169450	-0.174327	0.001459	-0.172868
	0.000001	0.000006	0.163014	0.000006
Industrial ratio	-0.068504	-0.069506	0.000575	-0.068932
	0.029937	0.034596	0.266131	0.034340
Log GDP	-0.010680	-0.010857	0.000101	-0.010756
	0.706258	0.716632	0.758276	0.716680
Log GDP squared	0.003089	0.003079	-0.000028	0.003051
	0.647294	0.664999	0.713979	0.665038
Rural density	-0.000337	-0.000341	0.000003	-0.000339
	0.448038	0.447035	0.549503	0.446850
Urban density	-0.000142	-0.000144	0.000001	-0.000142
	0.000000	0.000001	0.151160	0.000001
Curitiba	0.246863	0.251381	-0.002116	0.249265
	0.000776	0.001720	0.199942	0.001651
Intercept	0.043000			
	0.197629			

Note: Dependent variable is the CUs ratio. P-value is below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 1,000 draws and 10 m-steps for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Table 4: Spatial interactions and coefficient of quality with 10 m-steps and 1,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.009271			
	0.018412			
Coeff. quality 2010	2.006170	2.044481	-0.019894	2.024587
	0.000000	2.024587	0.052545	0.000000
Other coeff. quality 2010	0.047598	0.046818	-0.000457	0.046361
	0.298762	0.046361	0.432839	0.357414
Pop. Growth	-0.000046	-0.000052	0.000000	-0.000051
	0.827393	-0.000051	0.851236	0.821913
Agricultural ratio	-0.097775	-0.101095	0.001000	-0.100095
	0.000010	-0.100095	0.117243	0.000214
Industrial ratio	-0.040390	-0.041674	0.000418	-0.041256
	0.105803	-0.041256	0.287865	0.110357
Log GDP	0.006718	0.006271	-0.000065	0.006206
	0.776353	0.006206	0.806217	0.794730
Log GDP squared	-0.002303	-0.002186	0.000022	-0.002164
	0.674712	-0.002164	0.730517	0.703189
Rural density	-0.000532	-0.000562	0.000006	-0.000556
	0.210439	-0.000556	0.352319	0.200035
Urban density	-0.000005	-0.000005	0.000000	-0.000005
	0.686180	-0.000005	0.756034	0.706445
Curitiba	-0.200547	-0.207605	0.002026	-0.205579
	0.001138	-0.205579	0.102197	0.002151
Intercept	-0.025808			
	0.372629			

Note: Dependent variable is the coefficient of quality. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 1,000 draws and 10 m-steps for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

A.2 Tests of robustness

Table 5: Spatial interactions and CUs ratio with 1 m-step and 1,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.015591			
	0.048943			
CUs ratio 2000	2.496689	2.503930	-0.042608	2.461322
	0.000000	0.000000	0.054628	0.000000
Other CUs ratio 2010	0.002393	0.001981	-0.000046	0.001935
	0.916636	0.930292	0.920119	0.930683
Pop. growth	-0.000238	-0.000225	0.000004	-0.000221
	0.424124	0.447735	0.532125	0.447435
Agricultural ratio	-0.158445	-0.157292	0.002696	-0.154596
	0.000000	0.000000	0.080066	0.000000
Industrial ratio	-0.061420	-0.059479	0.001014	-0.058464
	0.038589	0.048624	0.204452	0.048505
Log GDP	-0.007360	-0.009311	0.000168	-0.009144
	0.781168	0.730343	0.743329	0.730660
Log GDP squared	0.002291	0.002695	-0.000050	0.002646
	0.720088	0.676374	0.686222	0.676887
Rural density	-0.000265	-0.000301	0.000004	-0.000296
	0.447976	0.417102	0.509725	0.417162
Urban density	-0.000150	-0.000150	0.000003	-0.000148
	0.000000	0.000000	0.065177	0.000000
Curitiba	0.269058	0.269791	-0.004644	0.265147
	0.000112	0.000093	0.088660	0.000089
Intercept	0.033778			
	0.309710			

Note: Dependent variable is the CUs ratio. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 1,000 draws and 1 m-step for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Table 6: Spatial interactions and coefficient of quality with 1 m-step and 1,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial Lag	-0.007961			
	0.014861			
Coeff. quality 2000	2.147355	2.159819	-0.017943	2.141876
	0.000000	0.000000	0.036036	0.000000
Other coeff. quality 2010	0.046348	0.046710	-0.000395	0.046315
	0.408003	0.417072	0.502236	0.416754
Pop. growth	-0.000087	-0.000099	0.000001	-0.000098
	0.731515	0.717683	0.724148	0.717865
Agricultural ratio	-0.120156	-0.121699	0.001038	-0.120661
	0.000029	0.000048	0.071360	0.000045
Industrial ratio	-0.045715	-0.046228	0.000400	-0.045827
	0.130484	0.129116	0.272974	0.128712
Log GDP	0.007792	0.007482	-0.000067	0.007415
	0.762524	0.772693	0.789936	0.772713
Log GDP squared	-0.002343	-0.002240	0.000020	-0.002220
	0.698956	0.713641	0.744413	0.713582
Rural density	-0.000506	-0.000507	0.000004	-0.000503
	0.192836	0.212209	0.317450	0.212040
Urban density	-0.000005	-0.000005	0.000000	-0.000005
	0.738243	0.725055	0.739453	0.725143
Curitiba	-0.222670	-0.223891	0.001851	-0.222040
	0.003560	0.003754	0.079546	0.003770
Intercept	-0.033999			
	0.277112			

Note: Dependent variable is the coefficient of quality. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 1,000 draws and 1 m-step for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Table 7: Spatial interactions and CUs ratio with 20 m-steps and 1,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.011955			
	0.054346			
CUs ratio 2000	2.472687	2.470931	-0.034086	2.436845
	0.000000	0.000000	0.076657	0.000000
Other CUs ratio 2010	0.001294	0.001089	-0.000015	0.001073
	0.958121	0.964834	0.968624	0.964852
Pop. growth	-0.000202	-0.000219	0.000003	-0.000216
	0.460280	0.451633	0.536278	0.451457
Agricultural ratio	-0.159695	-0.161560	0.002267	-0.159293
	0.000000	0.000001	0.122555	0.000001
Industrial ratio	-0.063010	-0.063393	0.000877	-0.062516
	0.055935	0.056882	0.232081	0.056611
Log GDP	-0.010399	-0.011258	0.000177	-0.011081
	0.736135	0.717775	0.721503	0.718445
Log GDP squared	0.003060	0.003214	-0.000050	0.003164
	0.668355	0.657203	0.668395	0.657908
Rural density	-0.000365	-0.000352	0.000004	-0.000348
	0.407417	0.412746	0.473736	0.413702
Urban density	-0.000146	-0.000145	0.000002	-0.000143
	0.000000	0.000000	0.090621	0.000000
Curitiba	0.257999	0.255121	-0.003521	0.251600
	0.000338	0.000518	0.117675	0.000510
Intercept	0.035427			
	0.333635			

Note: Dependent variable is the CUs ratio. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 1,000 draws and 20 m-steps for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Table 8: Spatial interactions and coefficient of quality with 20 m-steps and 1,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.009105			
	0.001292			
Coeff. quality 2000	2.035416	2.076427	-0.021004	2.055423
	0.000000	0.000000	0.018837	0.000000
Other coeff. quality 2010	0.040812	0.040646	-0.000400	0.040246
	0.408140	0.417392	0.472173	0.417175
Pop. growth	0.000000	-0.000006	0.000000	-0.000006
	0.998694	0.980572	0.962839	0.980778
Agricultural ratio	-0.103823	-0.108229	0.001113	-0.107117
	0.000141	0.000444	0.053866	0.000422
Industrial ratio	-0.047554	-0.049881	0.000515	-0.049366
	0.068153	0.066962	0.164687	0.066619
Log GDP	0.012694	0.013010	-0.000132	0.012879
	0.593051	0.601068	0.641245	0.600876
Log GDP squared	-0.003612	-0.003715	0.000038	-0.003677
	0.516659	0.517007	0.563700	0.516828
Rural density	-0.000469	-0.000471	0.000005	-0.000466
	0.174240	0.195699	0.269246	0.195671
Urban density	-0.000006	-0.000007	0.000000	-0.000007
	0.626042	0.612264	0.640851	0.612186
Curitiba	-0.200199	-0.205167	0.002085	-0.203082
	0.001990	0.003042	0.059805	0.002994
Intercept	-0.029702			
	0.359977			

Note: Dependent variable is the coefficient of quality. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 1,000 draws and 20 m-steps for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Table 9: Spatial interactions and CUs ratio with 1 m-step and 10,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.005140			
	0.056389			
CUs ratio 2000	2.482924	2.484895	-0.014194	2.470701
	0.000000	0.000000	0.095831	0.000000
Other CUs ratio 2010	-0.003825	-0.003323	0.000013	-0.003310
	0.900281	0.912417	0.947854	0.912257
Pop. growth	-0.000389	-0.000387	0.000002	-0.000385
	0.249177	0.248091	0.371734	0.248147
Agricultural ratio	-0.198933	-0.197727	0.001141	-0.196586
	0.000003	0.000004	0.121557	0.000003
Industrial ratio	-0.082875	-0.081705	0.000469	-0.081237
	0.035391	0.036242	0.205557	0.036217
Log GDP	-0.002954	-0.003300	0.000025	-0.003275
	0.933269	0.924846	0.915268	0.924984
Log GDP squared	0.001617	0.001675	-0.000011	0.001664
	0.844032	0.837278	0.839422	0.837426
Rural density	-0.000413	-0.000404	0.000002	-0.000402
	0.408927	0.413295	0.510039	0.413380
Urban density	-0.000147	-0.000147	0.000001	-0.000146
	0.000002	0.000002	0.117095	0.000002
Curitiba	0.253359	0.254765	-0.001453	0.253312
	0.003102	0.002947	0.160360	0.002948
Intercept	0.031586			
	0.455131			

Note: Dependent variable is the CUs ratio. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 10,000 draws and 1 m-steps for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Table 10: Spatial interactions and coefficient of quality with 1 m-step and 10,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.005395			
	0.014428			
Coeff. quality 2000	2.083261	2.074935	-0.011564	2.063371
	0.000000	0.000001	0.041013	0.000001
Other coeff. quality 2010	0.048372	0.048150	-0.000270	0.047880
	0.361493	0.362783	0.434970	0.362756
Pop. growth	-0.000195	-0.000193	0.000001	-0.000192
	0.435325	0.434361	0.484684	0.434388
Agricultural ratio	-0.120498	-0.120197	0.000681	-0.119516
	0.000026	0.000029	0.065659	0.000027
Industrial ratio	-0.047154	-0.047487	0.000268	-0.047219
	0.101485	0.097240	0.216053	0.097171
Log GDP	0.009978	0.010066	-0.000057	0.010009
	0.710938	0.708264	0.742678	0.708208
Log GDP squared	-0.002560	-0.002584	0.000014	-0.002569
	0.681432	0.678730	0.721658	0.678643
Rural density	-0.000330	-0.000323	0.000002	-0.000321
	0.310357	0.316166	0.399120	0.316184
Urban density	-0.000005	-0.000005	0.000000	-0.000005
	0.697017	0.687786	0.729164	0.687705
Curitiba	-0.208601	-0.206840	0.001156	-0.205683
	0.004653	0.005035	0.091795	0.005023
Intercept	-0.028195			
	0.424255			

Note: Dependent variable is the coefficient of quality. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 10,000 draws and 1 m-step for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Table 11: Spatial interactions and CUs ratio with 10 m-steps and 10,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.007539			
	0.069369			
CUs ratio 2000	2.495967	2.506382	-0.020690	2.485693
	0.000000	0.000000	0.080566	0.000000
Other CUs ratio 2010	-0.005525	-0.006300	0.000060	-0.006240
	0.853061	0.831965	0.834697	0.832145
Pop. Growth	-0.000334	-0.000321	0.000002	-0.000318
	0.318289	0.338173	0.442593	0.338137
Agricultural ratio	-0.195091	-0.194324	0.001616	-0.192707
	0.000001	0.000001	0.105033	0.000001
Industrial ratio	-0.083564	-0.082709	0.000683	-0.082026
	0.025659	0.028276	0.182906	0.028239
Log GDP	-0.003673	-0.004373	0.000051	-0.004322
	0.915589	0.900116	0.880971	0.900429
Log GDP squared	0.001730	0.001888	-0.000019	0.001869
	0.830145	0.815637	0.812098	0.815906
Rural density	-0.000446	-0.000439	0.000004	-0.000436
	0.370995	0.372566	0.476569	0.372608
Urban density	-0.000149	-0.000150	0.000001	-0.000149
	0.000001	0.000001	0.106328	0.000001
Curitiba	0.257427	0.260770	-0.002175	0.258595
	0.002245	0.002220	0.149811	0.002189
Intercept	0.029565			
	0.478434			

Note: Dependent variable is the CUs ratio. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 10,000 draws and 10 m-steps for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Table 12: Spatial interactions and coefficient of quality with 10 m-steps and 10,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.007860			
	0.029336			
Coeff. quality 2010	2.032120	2.023016	-0.017006	2.006010
	0.000000	0.000000	0.054477	0.000000
Other coeff. quality 2010	0.049377	0.048734	-0.000415	0.048319
	0.331595	0.330935	0.419984	0.330930
Pop. Growth	-0.000111	-0.000106	0.000001	-0.000105
	0.651782	0.661953	0.684167	0.662091
Agricultural ratio	-0.110865	-0.109444	0.000936	-0.108508
	0.000062	0.000076	0.088593	0.000073
Industrial ratio	-0.044297	-0.044561	0.000383	-0.044178
	0.106283	0.100042	0.246642	0.099914
Log GDP	0.009938	0.010105	-0.000085	0.010019
	0.697339	0.689017	0.724200	0.689013
Log GDP squared	-0.002748	-0.002781	0.000023	-0.002758
	0.646194	0.638565	0.680507	0.638569
Rural density	-0.000368	-0.000370	0.000003	-0.000367
	0.279075	0.274648	0.369824	0.274771
Urban density	-0.000005	-0.000005	0.000000	-0.000005
	0.713923	0.701541	0.750868	0.701395
Curitiba	-0.202580	-0.200935	0.001693	-0.199242
	0.003004	0.003034	0.101583	0.003045
Intercept	-0.036568			
	0.265536			

Note: Dependent variable is the coefficient of quality. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 10,000 draws and 10 m-steps for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Table 13: Spatial interactions and CUs ratio with 20 m-steps and 10,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.008327			
	0.010486			
CUs ratio 2000	2.495267	2.494873	-0.022160	2.472713
	0.000000	0.000000	0.025873	0.000000
Other CUs ratio 2010	-0.004671	-0.004121	0.000042	-0.004079
	0.867565	0.883087	0.880357	0.883221
Pop. Growth	-0.000360	-0.000350	0.000003	-0.000347
	0.289930	0.308498	0.389802	0.308398
Agricultural ratio	-0.194244	-0.193731	0.001746	-0.191985
	0.000002	0.000003	0.057662	0.000002
Industrial ratio	-0.081738	-0.081420	0.000738	-0.080682
	0.030961	0.032545	0.150980	0.032383
Log GDP	-0.005865	-0.005877	0.000057	-0.005819
	0.866068	0.865847	0.869622	0.865921
Log GDP squared	0.002521	0.002465	-0.000024	0.002441
	0.757650	0.762807	0.773068	0.762907
Rural density	-0.000380	-0.000396	0.000003	-0.000393
	0.429516	0.423205	0.492801	0.423140
Urban density	-0.000148	-0.000148	0.000001	-0.000146
	0.000001	0.000001	0.040652	0.000001
Curitiba	0.256395	0.256319	-0.002273	0.254046
	0.001806	0.001864	0.071690	0.001863
Intercept	0.033295			
	0.419546			

Note: Dependent variable is the CUs ratio. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 10,000 draws and 20 m-steps for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Table 14: Spatial interactions and coefficient of quality with 20 m-steps and 10,000 draws

Variable	Coefficient	Direct	Indirect	Total
Spatial lag	-0.028634			
	0.395237			
Coeff. quality 2010	2.095744	2.081309	-0.010148	2.071161
	0.000000	0.000000	0.126884	0.000000
Other coeff. quality 2010	0.042334	0.042886	-0.000205	0.042681
	0.417894	0.407404	0.531560	0.407304
Pop. Growth	-0.000122	-0.000115	0.000001	-0.000115
	0.622875	0.637291	0.663719	0.637450
Agricultural ratio	-0.112345	-0.110796	0.000547	-0.110249
	0.000081	0.000097	0.155555	0.000096
Industrial ratio	-0.043165	-0.042758	0.000204	-0.042553
	0.127466	0.128396	0.305998	0.128478
Log GDP	0.009026	0.008900	-0.000039	0.008862
	0.722778	0.723182	0.790352	0.723044
Log GDP squared	-0.002489	-0.002484	0.000011	-0.002473
	0.679850	0.676647	0.757503	0.676481
Rural density	-0.000372	-0.000369	0.000002	-0.000367
	0.304807	0.299605	0.447697	0.299588
Urban density	-0.000005	-0.000005	0.000000	-0.000005
	0.708593	0.704741	0.781924	0.704572
Curitiba	-0.211293	-0.208959	0.001024	-0.207935
	0.003677	0.003984	0.182370	0.003970
Intercept	-0.004810			
	0.075243			

Note: Dependent variable is the coefficient of quality. P-value are below the estimated coefficient. Estimated with the spatial Bayesian tobit estimator with 10,000 draws and 20 m-steps for 399 observations with 333 censored at 0. Column 2 displays the coefficient estimated, Column 3 the direct effect, Column 4 the indirect effect and Column 5 the total effect. 40 micro-regions dummies are used but results are not presented to save space.

Figure 1: Paraná in Brazil

Paraná -- Encyclopedia Britannica Online http://www.britannica.com/bps/media-view/129038/0/1/0

Paraná

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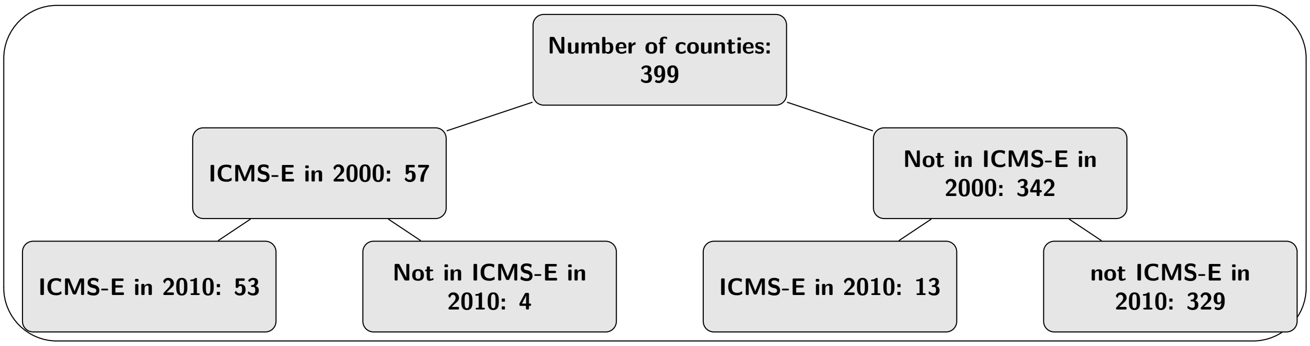
Source: Encyclopaedia Britannica

Figure 2: Evolution of the creation of all CUs in Paraná between 1991 and 2010

Note: Evolution of the areas (in hectare) of all conservation units (federal, state and municipal) between 2000 and 2010.

Source: Authors' calculation from May et al. (2002) and Grieg-Gran (2000) and authors' collected data.

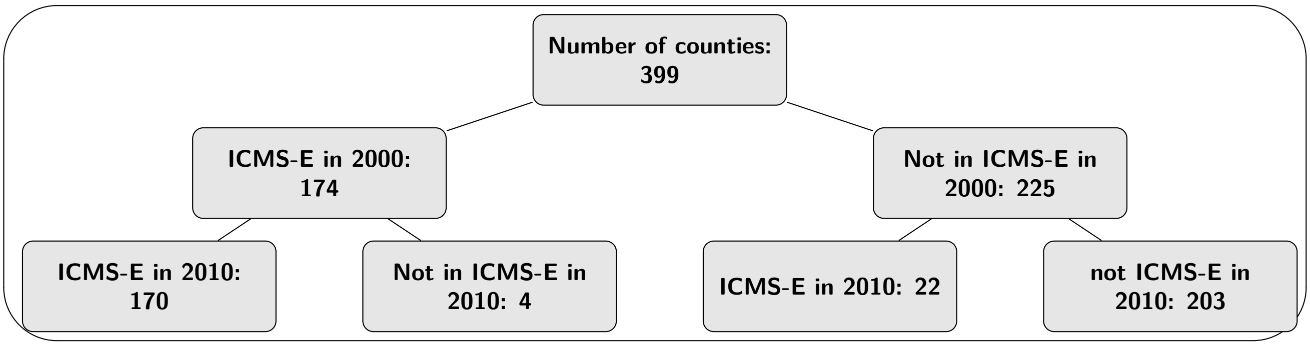
Figure 3: Evolution of the number of counties in the ICMS-E for municipal CUs



Note: Evolutions between 2000 and 2010 of the number of counties concerning by the ICMS-E for the creation of municipal CUs.

Source: drafted by the authors

Figure 4: Evolution of the number of counties in the ICMS-E



Note: Evolutions between 2000 and 2010 of the number of counties concerning by the ICMS-E, whatever the CUs.

Source: drafted by the authors