Ecological Fiscal Incentives and Spatial Strategic Interactions: the Case of the ICMS-E in the Brazilian state of Paraná

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Résumé / Abstract

The ICMS-Ecológico is a fiscal transfer mechanism from states to municipalities, implemented in the early 1990's in Brazil, to reward municipalities for the creation and management of protected areas. This paper investigates the efficiency of this mechanism by testing for the presence of interactions among Brazilian municipalities in their decision to create conservation units, in the state of Paraná, between 2000 and 2010. We estimate a Bayesian spatial Tobit model in order to analyze the behavior of municipalities. The empirical investigation reveals strategic substitutability in municipalities conservation decisions.

Mots clés /Key words : Land use, Biodiversity, Fiscal federalism, Interactions, Spatial Tobit model, Brazil

Codes JEL / JEL codes : H23, 013, Q57

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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 and with little regard to the environmental consequences" (Andersen et al., 2002, p.34). However, the growing interest by the international community in environmental problems and the worsening of the economic situation in Brazil led to a change in policy making in the late 80's. Indeed, several programs sprang up with the purpose of promoting sustainable development (see for example Di Bitetti et al. (2003) on biodiversity management and Feres and da Motta (2004) on water management). This consideration of environmental issues in development policies was of the utmost importance since Brazil is recognized as one of the planet's major reserves of forests and biodiversity. Myers et al. (2000) point out that Brazil is estimated as hosting one-sixth of the endemic plant species of the earth's, to cite but just one example.

Even if a political will at the federal level is important to protect the environment, the state of the biodiversity is mainly influenced by local activities. One solution to protect flora and fauna at the local level, is the establishment of protected areas. However, protected areas involve local conservation costs, in terms of land use restrictions, while generating both local and global conservation benefits. These positive externalities are not taken into account by the local entities, which leads to an under-provision of the environmental public good (Perrings and Gadgil, 2003; Ring, 2008b; Barton et al., 2009, among others)[1]. As explained by Farley et al. (2010), five mechanisms are widely recognized for internalizing externalities and ensuring the provision of local public goods: prescription, penalties, persuasion, property rights and payments. The main idea is to provide incentives for local actors to engage in conservation efforts for promoting sustainable land use.

Among mechanisms developed to promote sustainable development and urge local actors to produce local public good, the ICMS-Ecológico or ICMS-E ("*Imposto sobre Circulacão de Mercadorias e Servicos - ecológico*" or "*Ecological value added tax*"), which

[1]There are few incentives for local actors to encourage local conservation activities when environmental benefits cross local boundaries.

lies in the class of payments for environmental services, is of particular interest. The ICMS-E is a fiscal transfer mechanism implemented in order to promote land conservation at the local level. It is not only designed for Amazonian states[2] but also aims at protecting the Atlantic forests which are identified as a Biodiversity Hotspot and are threatened by fragmentation, mainly due to agricultural expansion (see Brooks and Balmford (1996), Brooks et al. (1999) or Putz et al. (2011) for example).

The ICMS-E is an intergovernmental ecological 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 or CUs) and watershed reserves. Intergovernmental fiscal transfers are thus used to aid in internalizing the problem from the cost side by compensating municipalities for foregone opportunities, i.e., potential revenues lost due to conservation measures (Kumar and Managi, 2009). Indeed, one reason for its implementation was the demand by municipalities hosting federal or state managed protected areas to be compensated for the cost of providing this public good. Yet it was also designed to incite municipalities to create new protected areas.

Since its implementation in the early 90's, the ICMS-E has been a real success in terms of CU creation. By 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). In addition, the mechanism has several interesting features. It is a decentralized system, which implies that decision-makers benefit from better information. The mechanism is implemented without any external financing (the redistributed funds are collected from tax on goods and services in the concerned state).Finally, the transaction costs are very low[3]. As such, 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 its attractiveness, very few studies have been carried out on the ICMS-E.

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

[3]According to Vogel (1997), in 1995, in the state of Paraná, 30,000,000 dollars were redistributed to the municipalities for an administrative cost of only $32,000.

Grieg-Gran (2000) analyzes which municipalities have benefited from the ICMS-E reform and 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[4]. Finally, Ring (2008a) highlights the appeal of the ICMS-E by providing a clear description of the mechanism, along with trends 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, no one has questioned the mechanism's efficiency. Yet, the ICMS-E is a decentralized policy, and as stated by Oates and Portney (2003), the decentralization of a policy could lead to an inefficient outcome if a race to the bottom between agents in the creation of local public good is observed. However, as we will see in our theoretical section, there are several reasons for expecting municipalities to influence each other when deciding whether or not to create CUs. More precisely, the interactions between counties can evolve in two directions: their decisions can be substitutes or complements, and the presence of complementarities between decisions can indicate the presence of a race to the bottom[5].

Therefore, the aim of this paper is to test one condition for the efficiency of the mechanism, by investigating the presence of interactions between counties when they decide whether or not to protect their lands. We collected data on the ICMS-E for 399 municipalities of the state of Paraná between 2000 to 2010. This state constitutes a case of primary interest because it was the first to adopt the mechanism in question in 1991 and was a pioneer in introducing a quality-weighting factor for the redistribution of the ICMS-E[6].

[4]Several mayors were interviewed and asked why they had used the ICMS-E mechanism.

[5]The terms "county" and "municipality" will be used interchangeably thoughout the rest of the paper.

[6]The transparency of the system is also an interesting feature in this state, since all information concerning the nature of the park, its area and the amount of money received from the ICMS-E by a municipality can be downloaded from the internet.

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 discuss the possible interactions between municipalities and assess them through the Bayesian spatial Tobit estimator proposed by LeSage (1999, 2000) and LeSage and Pace (2009). This estimator allows us to test the presence of interactions among municipalities in their conservation decisions. Negative spatial interactions among municipalities are found, suggesting that conservation decisions are strategic substitutes.

The paper is organized as follows. Section 2 discusses the context in which the ICMS-E was implemented in the Brazilian state of Paraná. Section 3 presents the theoretical hypothesis explaining the nature of interactions between municipalities in providing conservation units. Section 4 details the estimation strategy, while results are analyzed in Section 5. Section 6 concludes with the possible policy implications.

2. ICMS-E and conservation units in Paraná

2.1. Presentation of the ICMS-E

Brazil is federation with 27 states which capture most of their revenue from taxes on the circulation of goods and services, i.e., a value-added tax (VAT), called the ICMS (*Imposto sobre Circulacão de Mercadorias e Servicos*). States must return 25% of collected revenue from sales taxes to municipalities according to 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 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 size or health expenditures).

In 1992, the state of Paraná (see the geographical map 1, page 27, on Brazilian states) was the first to introduce ecological criteria in the redistribution of the ICMS-E. The state rewards municipalities for having protected areas (biodiversity) and watershed reserves (water quality) within their boundaries[7]. The initiative was followed by several states[8]

[7]See May et al. (2002, P.175) for a more complete presentation of the legislative process in Paraná.

[8]14 other Brazilian states have already introduced the ICMS-E, including São Paulo (1996), Minas

and this new fiscal incentive tool is now called ICMS-Ecológico.

In Paraná, the law stipulates that 5% of the ICMS revenues redistributed to municipalities should be in proportion to their environmental performance. Half of this (2.5%) is used to reward municipalities for the creation of conservation areas (also called "conservation units" (CUs)). 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). It is worth noting 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. in addition, since only a fixed pool of money is available in any given year, the municipalities compete with each other to receive the money. The other half (2.5%) of the pool of money redistributed according to environmental criteria, is for those municipalities that have watershed protection areas which partly or completely provide services for public drinking water systems in neighboring municipalities[9]. The main motivation of this fiscal redistribution policy was initially to compensate municipalities for the opportunity costs of conservation areas (often decided at 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, allowed for an increase in the number and area of both state and municipal protected areas.

2.2. The Municipal Conservation Factor

A stated before, the state of Paraná was the first to use environmental criteria to redistribute the ICMS. It was also a pioneer in taking into account the quality of protected areas (Farley et al., 2010; May et al., 2002). The state redistributes the ICMS according

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 (2008a)).

[9]See, for instance, the case of the municipality of Piraquara which has 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, 2008a).

to the relative Municipal Conservation Factor (MCF) of a municipality compared to the sum of overall MCF in the State. The MCF is derived from the ratio of CUs to total municipal area weighted by a quality factor.

The MCF has thus two components: a quantitative and a qualitative one. The former is the percentage of municipal land area under protection in the total area of the county. The latter evaluates the quality of the conservation unit on the basis of variables, such as biological and physical quality, the quality of water resources in and around the CUs, how important is the CU in the regional ecosystem, the quality of planning, implementation, maintenance and the legitimacy of the unit in the community[10]. These factors also reflect the improvements of CUs over time as well as their relationships with the surrounding areas[11]. The quality of each CU is assessed by regional officers of the Environmental Institute of Paraná (Instituto Ambiental do Paraná, IAP). Their evaluation is then transformed in a score weighting the quantitative ratio[12].

The Ecological Index of the municipality i is calculated as follows (this part is adapted from Loureiro et al. (2008, p.22-23) and Ring (2008a)).

First is the calculation of the Biodiversity Conservation Coefficient (BCC_{ji}) of each CU j in the municipality i as follows:

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

where $Area\ CU_j$ and $Area\ municipality_i$ are the area of the conservation unit j and the area of the municipality i respectively. Each BCC_{ij} is multiplied by a conservation factor FC_n which is variable and assigned to protected areas according to management category n (see Table 1 page 28 in the Appendix for more information on the weighting factor of

[10] See Farley et al. (2010).

[11] For instance, the quality factor of a CU will increase if the county creates buffer zones around this area.

[12] According to May et al. (2002), the quality index is also assessed regarding to "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".

each protected area).

Next each BCC_{ij} is assigned an ESC criterion to account for the variation of the "quality" of protected area as follows:

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

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

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[13].

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 Z is the number of municipalities in the state receiving funds from the ICMS-E.

As explained earlier, a protected area can be managed at the federal, state or municipal level. In this paper, we focus only on the creation of parks managed at the municipal level, since it is only at this level that the municipality has full power over the creation or destruction of parks. We are, therefore, primarily interested in the BCC and MCF index for municipal parks.

[13]For instance, Curitiba had 15 conservation units in 2000.

2.3. Evolution of conservation units in Paraná

A brief overview of the evolution of the number of counties in the ICMS-E for all CUs between 2000 and 2010 is given by Figure 2 in the Appendix (page 29). There were 174 counties in the ICMS-E (i.e., receiving funds for the presence of CUs in their territory) in 2000, compared to 192 in 2010, . The number of counties in the fiscal mechanism has thus increased by 22 in 11 years, while 4 counties have decided to leave the mechanism (i.e., convert their parks for economic uses).

As stated before, in our analysis, we focus only on the creation of parks managed at the municipal level. Therefore, as shown by figure 3 (see Appendix, page 29), the number of counties which have received funds for the creation of municipal parks has increased by 9 counties between 2000 and 2010 (57 in 2000 compared to 66 in 2010) over the 399 counties in the dataset. As a consequence, 342 and 333 counties did not receive fiscal transfers from the ICMS-E for the creation of municipal CUs in 2000 and 2010 repsectively. Moreover, it is worth noting that 4 counties have converted their municipal CUs for economic purposes during the last decade, and no longer receive funds from the ICMS-E, while 13 new counties have received fund from the ICMS-E for the creation of their first municipal CUs.

Further, as we can see in Table 3, the average size of the area of municipal parks by county is about 1,172 hectares in 2010, representing on average 2 percent of the municipality's area. By comparison, federal and state managed parks covered about 10,030 hectares in average by county (11 percent of the total municipal area).

[insert table 3 here]

Finally, the Figure 4 (see Appendix, page 31) shows the evolution of the area of all CUs by hectare at the state level[14]. The evolution of CUs can be divided into two decades. In the first decade, the creation of CUs increased sharply, while in the second decade (from

[14] Of course, these figures concern all CUs, i.e., federal, state and municipal CUs whereas only the evolution of municipal CUs created is of interest in our study. Unfortunately, we do not have reliable data on the creation of municipal CU's prior to 2000.

2000), the creation of CUs increased more reasonably. Thus it can be assumed that the creation of CUs in the state of Paraná through the ICMS-E mechanism has reached a kind of stationary level.

3. Analytical framework

3.1. Why test for the presence of interactions between conservation decisions?

As pointed out by Barton et al. (2009), ecological fiscal transfers such as the ICMS-Ecologico *"provide an interesting and rather new case for comparative analysis on the effectiveness and efficiency of biodiversity conservation instrument."* Therefore, and as explained in the introduction, the aim of this work is to contribute to this area of research, by testing one condition for the efficiency (defined in terms of parks creation) of the ICMS-E[15].

The ICMS-E is a decentralized fiscal transfer mechanism from states to municipalities. Yet, as stated by Oates (see for instance Oates and Portney (2003)), one condition for efficient decentralization is the absence of interactions between agents. With respect to the ICMS-E, this point was first underlined by Ring (2008a), who wrote: *"Despite the general suitability of many land-use issues for being assigned to lower governmental levels, spatial externalities may require different, more appropriate solutions."* Indeed, the mechanism would be inefficient, if for example, a race to the bottom in park-creation decisions were observed, leading to a low overall level of area under protection in the state. Testing the nature of (horizontal) interaction between municipalities' decisions is therefore crucial to assess the efficiency of the mechanism[16].

[15]Indeed, we define efficiency here in relation to the main goal of the mechanism, which is the creation of protected areas in order to preserve biodiversity. Other definitions of efficiency could be measured in terms of avoided deforestation in the overall state, but this is beyond the scope of this paper.

[16]See Fredriksson and Millimet (2002) for another example of testing for the presence of horizontal interactions in the case of environmental criteria.

3.2. What is the likely nature of these interactions?

In reality, the interactions between a county and its neighbors can evolve in two directions. On the one hand, the level of parks in a county and one of its neighbors could be strategic complements, meaning that the utility of a county's creation of parks increases with the creation of parks by its peers. On the other hand, the level of parks in a county and one of its neighbors could be strategic substitutes, meaning that the utility of a county's creation of parks decreases with the creation of parks by its peers. Indeed, there exist arguments for both possibilities, and we will expose these arguments in the following paragraphs. To develop and present our arguments, we consider, that with a given plot, a municipality can choose between two options: designating an area as *protected* or *unprotected*. A protected area means the creation of a municipal park whereas an unprotected area refers to the development of economic activities (industry, agriculture, logging,...).

A strategic complementarity in municipalities' conservation decisions would mean that a county has an interest in following the decisions of its neighbor. For instance, the utility gained from the creation of a park increases (decreases) if the neighbor is creating more (less) protected areas. This could be motivated by three main factors. First, according to the Tiebout theory of "voting with the feet" (Tiebout, 1956), a new firm could choose the municipality where the environmental standards are lower to establish itself. This could lead to a race to the bottom between municipalities if ever they want to attract the firm. Second, a farmer could choose the county where its potential development is the higher (i.e., where there are less protected areas). Therefore, this could lead the municipalities to compete again based on this criterion. Finally, as pointed by Andam (2007), the establishment of protected areas in a county can lessen the development of local market infrastructure, such as transport. It could then reduce the profitability of economic activities in neighboring counties, which do not enjoy these infrastructures. The spillovers from the creation of a park in one municipality can thus be positive and induce the creation of a park in the neighboring municipality[17].

[17] Or the other way around, the development of infrastructures can exacerbate deforestation (see for example Pfaff (1999)).

However, if we think in terms of the profitability of the two options, development of economic activities or creation of parks, we could also expect the decisions to be strategic substitutes. This could come through four channels. First, the creation of a protected area in one municipality could constrain economic activity and lead to a worker surplus in this municipality. The displacement of the worker surplus to the neighboring municipality could bring down the wage level and favor the decision to develop economic activities over choosing the protection option. Second, the creation of new CUs decreases the stock of lands available for economic production in a given municipality. Therefore, it increases the demand of lands for economic production in the neighboring municipalities. Depending on the relative profits from economic activities, the municipalities could be incited to increase their supply of land for economic activities (by decreasing their number of CUs), in order to attract farmers and firms when their neighbors are creating protected areas. We could therefore, in this case again, expect protection decisions to be strategic substitutes. Moreover, we could think of an effect traditionally highlighted in studies on deforestation leakages. The creation of a park in a municipality will decrease the availability of the wood resources in this municipality and then increase the logging in the neighboring municipalities (a phenomenon also referred to as outsourcing by Aukland et al. (2003)). The creation of parks in a municipality will therefore go along with the destruction of protected areas or the reduction of incentives to create new ones in the neighboring municipalities. Finally, a protected area is also a public good, that local population can enjoy. Yet, the distance between two municipalities is relatively small, and the citizens from one municipality could go to the neighboring municipality to enjoy the recreation of a park. A municipality could then decide to "free ride" and create less parks if the neighboring municipalities are providing this local public good.

Considering the arguments expounded above, we could expect conservation decisions to be strategic substitutes or strategic complements. The following section 4 will deal with the empirical strategy implemented in order to distinguidh between the two hypothesis.

4. Empirical strategy

4.1. Econometric model and data used

As explained by Anselin (2001) the spatial lag model is appropriate when the focus of interest is the assessment of the existence and strength of spatial interaction. This fitting with our question of interest, we therefore estimate a Spatial AutoRegressive (SAR) model, where the spatially lagged endogenous variable is a weighted sum of neighbors' decisions, such as:

$$P^* = \rho W P^* + \beta X + \epsilon \tag{6}$$

where P^* is a $K \times 1$ vector of the propensity to create municipal CUs by a county. K is the number of municipalities in the sample, here 399. X is a $M \times K$ matrix of our M explanatory variables influencing the choice between the protected and unprotected options and β is a vector of their corresponding coefficients. ϵ is a $K \times 1$ vector of residuals. WP^* is a spatially lagged endogenous variable, where W is a $K \times N$ 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 did not create municipal CUs. Having 0% of municipal CUs is a corner solution, it does not mean that each municipality is in exactly the same situation. We can therefore argue that censoring is at stake and that there exist negative profits unmeasured by our dependent variable exist. Therefore, we have:

$$p_j = 0 \quad if \quad p_j^* \leq 0$$
$$p_j = p_j^* \quad otherwise,$$

where p_j is the observed dependent variable. Following the traditional approach in land use studies initiated by Chomitz and Gray (1996), we account for this censoring using a tobit model, where the conditional distribution of p_j given all other parameters is a truncated normal distribution constructed by truncating distribution from the left at 0.

The expanded form of the spatial autoregressive tobit model is the following:

$$\begin{aligned} p_j^* &= \rho \sum_{j \neq k}^{K} w_{jk} p_k^* + \beta p_j^{init} + \delta FED_j + \alpha_1 ind_j + \alpha_2 agr_j + \alpha_3 inc_j \\ &+ \alpha_4 incsq_j + \alpha_5 pop_j + \alpha_6 urb_j + \alpha_7 rur_j + \alpha_8 Curitiba_j + \mu_r + \vartheta_j, \end{aligned} \quad (7)$$

where the observed dependent variable, p_j, is the MCF of municipal parks of county j in 2010 defined in Section 2.2 and p_j^{init} represents the initial MCF in 2000. The MCF in 2000 is introduced to account for the initial conditions determined by the first period of implementation of the mechanism.

All other variables are control variables and are assumed to have an impact on the land allocation decision-rule. First FED_j is introduced which is the MCF for other CUs (federal and state managed) in the county i in 2010. This variable can have both negative and positive expected effects. Given that the area of a county is by definition fixed, more non-municipal CUs increase the scarcity of land. In this context, the effect of a land allocation decision is ambiguous. First, the creation of federal or state level protected areas could decrease the amount of land to be potentially converted into municipal conservation areas. FED_j would therefore have a negative effect on p_j. However, wa can assume that land scarcity increases land price, discouraging investment in this county since the costs for the *unprotected* option go up. knowing this, the municipality may decide to protect the land and create CUs to earn more money from the ICMS-E[18].

The variables ind_j and agr_j respectively are the average ratio of the industrial GDP on the total municipal GDP between 2000 and 2008, and the average ratio of the agricultural GDP on the total municipal GDP between 2000 and 2008[19]. These variables measure the development projects and are assumed to increase the opportunity cost of creating conservation units. They are thus negatively linked to the propensity to create municipal parks.

[18]This can be seen as a kind of vertical interaction.

[19]2008 is the last year for which data are available.

The income (inc_j) is measured by the average of the GDP per capita between 2000 and 2008 (taken in logarithme). Moreover, the effect of the variable inc_j could be more ambiguous since richer counties could be better off preserving their forests for ornamental purposes. To test this idea, the quadratic term in log ($incsq_j$) is used. Thus, (1) poorer counties are assumed to be more inclined to create parks since their comparative advantages to proceed in *unprotected* activities are lesser than for richer counties, and (2) richer counties are also assumed to create more parks for ornamental aims. The quadratic term $incsq_j$ is thus assumed to be negative, i.e., the income effect on the creation of parks is U-inversed.

The variables pop_j, urb_j and rur_j are the average annual population growth, urban density (per km^2) and rural density (per km^2) respectively between 2000-2010. These variables are proxies for labor supply, and demand of lands and are expected to have a negative effect on p_j.

$Curitiba$ 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. Indeed, Curitiba strongly desires to be a green city[20,21].

We also introduce micro-region dummies (μ_r), which represent legally defined administrative areas consisting of groups of municipalities bordering urban areas. These dummies enable us to check for unobserved fixed effects shared by neighboring counties. In the state of Paraná, 39 micro-regions are censused for 399 counties.

Data concerning CUs (p_j, p_j^{init} and FED_j) are taken from the ICMS-E's official website. All other variables come from the IPEA database (see Table 2 page 30 in the Appendix for more information on descriptive statistics)[22].

[20]Note that the 2011 UN-Habitat report quoted Jaime Lemer the mayor of Curitiba: "The city is not the problem, it is the solution. And it is a solution for the problem of climate change." (United Nations, 2011)

[21]Note that in a standard cross section, it would be akin to dropping the observation. However, it is different in a SAR model, since the municipality behavior influences the other decision through the spatially lagged endogenous variable.

[22]Monetary variables are taken in constant values (2000R$).

4.2. Estimator

The estimation of parameters from the spatial autoregressive Tobit model represents a computational challenge and cannot be done via analytical methods. Indeed, it is impossible to use maximum likelihood due to multiple integrals in the likelihood function. Therefore, the econometrician must turn to simulation methods, such as EM algorithm or Bayesian estimation. We choose to rely here on the bayesian approach developed by LeSage (1999), LeSage (2000), LeSage and Pace (2009) and applied by Autant-Bernard and LeSage (2011), due to its computational simplicity and the possibility to easily account for heteroscedasticity in the error terms in this framework[23].

In this approach, the model parameters are estimated via MCMC (Monte Carlo Markov Chain) procedure, with a chosen number of n draws, such as estimator convergence is achieved. The posterior mean and standard deviation of parameters estimated at each draw will then be used as parameter values in the displayed results. Furthermore, the unobserved negative profits associated with the censored 0 observations are considered as parameters to estimate. The procedure uses the Geweke m-steps Gibbs sampler to produce draws from a multivariate truncated normal distribution in order to generate the unobserved negative profits associated with the censored 0 observations[24,25].

4.3. 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 6. It can be rewritten as:

$$P^* - \rho W P^* = \beta X + \epsilon \tag{8}$$

[23] Our choice is similar to the one adopted by Albers et al. (2008) when studying the interactions between private and public park creation in the United States.

[24] The m-steps correspond to the number of draws used to generate the unobserved negative profits, realized at each n draw.

[25] 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).

$$P^*(I_N - \rho W) = \beta X + \epsilon \tag{9}$$

$$P^* = (I_N - \rho W)^{-1}\beta X + (I_N - \rho W)^{-1}\epsilon \tag{10}$$

As we can see from Equation 10, $\frac{\partial p^*}{\partial x'} \neq \beta$, 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 impact). 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 because of the spatial spillovers (indirect impact). Computation details of these impacts are clearly described in (LeSage and Pace, 2009, (p.33-39)).

Finally, note that estimated coefficients from the Tobit model are not the marginal effects of each explanatory variable on the observed dependent variable[26]. Therefore we can interpret the signs of the direct and indirect effects but not their magnitudes.

5. Results

5.1. Neighboring effects and created CUs

We estimated the influence of neighbors' decisions as well as several economic indicators on a municipality's propensity to create parks. The Municipal Conservation Factor, implemented by the state of Paraná to redistribute the ICMS-E, is used as dependent variable. As explained in Section 2.2, the MCF is derived from the ratio of CUs on total municipal area weighted by a quality factor. In all regressions, the contiguity spatial weight matrix is used to represent the prior strength between two counties. Our results come from the estimation of a Baysesian spatial Tobit model using one step in the Gibbs sampler and 1,000 draws in the MCMC procedure[27]. Our main results are presented

[26]Basically, the coefficient is the marginal effect on the latent dependent variable. See the pioneering article of McDonald and Moffitt (1980) and Wooldridge (2001, pp 521–524) for more details.

[27]With 10% of the draws used as burn-in.

in Table 4, where the first column presents the value of the coefficients (β), the second column the value of the direct impact of the explanatory variable, the third column the indirect impact and the fourth the total impact.

[insert Table 4 here]

Negative spatial interactions between counties are found ($\rho < 0$) suggesting that a county is more inclined to create municipal CUs if their neighboring counties decrease the number of their CUs. It seems more profitable for a county to convert its natural land for agricultural or industrial activities if their neighboring counties have opted to create CUs and be awarded by the ICMS-E. Moreover this result could explain the stable trend in the creation of municipal CUs in the last decade after a strong upward trend in the early years of the implementation of the ICMS-E, as described in Section 2.3.

Concerning the other economic factors assumed to have an effect on the land allocation rule-decision of a county (through their effects on the differential profit between land use options), the population variables have the expected negative coefficient but are not significant.

Moreover, the structure of a county's economy is found to be important in explaining its propensity to create municipal CUs. In fact, the higher the share of agriculture in a municipality is, the lower the propensity to create municipal CUs. This result reveals the role of economic activities in the propensity to create CUs. Counties that are more developed in terms of agricultural activities can be more encouraged to develop their activities to earn money from the ICMS, which awards counties on the basis of their value added created.

Besides, Table 5 provides the estimated direct, indirect and total effects of each explanatory variable. We observe an indirect effect of lower magnitude and of the opposite sign compared to the direct effect, which is due to the substitutable nature of conservation decisions. For instance, we observe a positive indirect effect of the agricultural GDP, which mean that an increase in the agricultural ratio in a given region will increase the creation of parks in neighboring regions.

5.2. Robustness checks

5.2.1. Taking only account of the size of protected areas

As our first robustness check, we use a different measure of the environmental performance of a county. We choose to use only an extensive measure of protection as dependent variable: the Biodiversity Conservation Coefficient (see Section 2.2). The BCC is the ratio of protected areas on total land. This allows us to check the robustness of our first result (the substitutability in conservation decisions) and to see if the driving forces tested influence the way a county chooses to improve its of land protection, i.e., in an intensive or extensive manner. Table 5 presents results for the BCC as dependent variable.

[insert table 5 here]

Negative spatial interactions between counties are also found, thus confirming the negative effects of the creation of CUs by neighboring counties on a coounty's propensity to create CUs.

Concerning other economic factors, the negative effect of agricultural activities is still found, suggesting that counties whose economies are based more on agriculture are less prone to increase their level of CUs. Interestingly, the density of urban population and the industrial GDP are now factors which threaten protection. It is worthy to note that these factors have a negative effect on the extensive component of protection (the BCC), but not when we take into account the intensity of the protection (the MCF). This suggests that urban areas with high population density and industrial based economy counties care as much about the environment as others, but choose to protect their land in an intensive rather than in an extensive manner.

5.2.2. Checking the consistency of the estimator

Since the Bayesian spatial Tobit is a new estimator and few researchers have used it, we provide several robustness tests on the estimator itself. Indeed, to our knowledge, it has been proposed in the article of LeSage (2000) and the manuals of LeSage (1999) and LeSage and Pace (2009), but, to the best of our knowledge, has only been applied in Autant-Bernard and LeSage (2011). The main issue concerns the consistency of the estimator. We assess it by alternatively and simultaneously increasing the number of m-steps in the Gibbs sampler and the number of n-draws in the MCMC procedure. The basic assumption is that if the inferences are identical, the estimator can be assumed to be consistent.

The first robustness check on the number of steps in the Gibbs sampler process aims at testing the accuracy of the computed vector of parameters which replaces the unobserved latent utility (here for $p^*_{j,t} < 0$) (LeSage and Pace, 2009, p.287).

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 stability in the parameter values found.

Table 6 provides results with the MCF coefficients as the dependent variable for respectively 1, 10 and 20 steps of the Gibbs sampler process, with 1,000 and 10,000 draws. The spatial interactions are still found to be negative and significant as are the initial municipal conservation factor and the agricultural ratio. Therefore, we do not conclude that the estimator is inconsistent.

[insert table 6 here]

6. Conclusion

The aim of this paper was to assess the efficiency of the ICMS-E by testing the presence of strategic interactions between Brazilian counties in the state of Paraná. It 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 fiscal scheme is important since it is a form of payment for environmental services which can be implemented without any external source of financing and at very low transaction costs. However, since the system is decentralized, its efficiency could be threatened by the presence of interactions between municipalities when they decide to set aside their lands for protection.

Therefore, this study tries to investigate whether the behavior of neighboring counties, in terms of created municipal CUs, had an effect on a county's propensity to create municipal CUs between 2000 and 2010 in the state of Paraná. The results do not highlight a race to the bottom between counties which would have finally questioned the efficiency of the ICMS-E. However, we do observe strategic substitutability between conservation decisions. This means that the utility gained from the creation of a park decreased (increased) if the neighbor created more (less) protected areas. This seems to have led the mechanism to reach an equilibrium in the last decade.

In a way, the mechanism seems to be efficient, because our results suggest that the behavior of municipalities is driven by an optimization process and that take their neighbors' decisions into account when making their own decisions. However, there is no reason for the shared pool of money to lead to the optimal level of land set aside for protection. Moreover, it seems that municipalities do not act as good samaritans providing public goods but are really subject to a financial calculations. Thus, the design of the ICMS-E, via the definition of the quality weighting factor, seems crucial.

To conclude, the ICMS-E has had great success and has increased the number of CUs in Paraná. This experience should be viewed as a new and interesting tool to finance local public good without the need for external funding. However, policy makers should be aware of the potential negative spatial interactions which can occur, since these could be an obstacle to conservation objectives such as the creation of biodiversity corridor.

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7. Appendix

7.1. Geographical location of the state of Paraná in Brazil

Figure 1: Paraná in Brazil

Source: Encyclopaedia Britannica

7.2. Calculation of the ICMS-E: the conservation factor

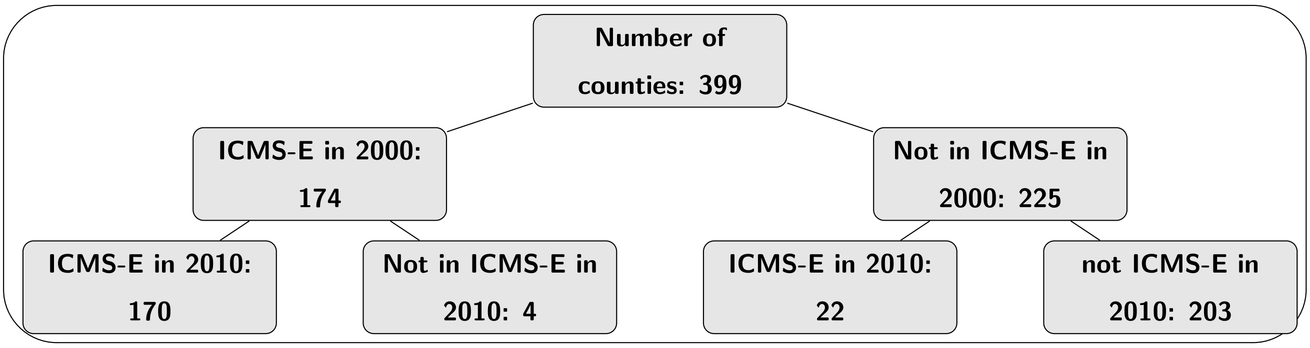
Table 1: Conservation factor FC_n for different management categories n of protected areas in Paraná

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.

7.3. Descriptive statistics

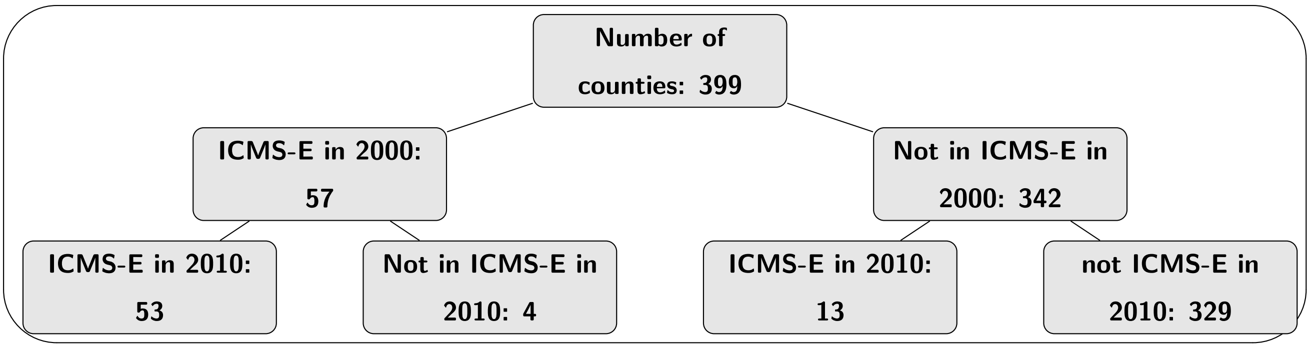
Figure 2: Evolution of the number of counties in the ICMS-E



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

Source: drafted by the authors

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

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
Agricultural GDP/GDP	0.3051	(0.1484)	0.0004	0.6235	399
Industrial GDP/GDP	0.1439	(0.1148)	0.0288	0.8336	399
GDP	5.647	3.305	(2.278)	42.817	399
GDP squared	42.786	(105.342)	5.189	1833.269	399
Population growth	2.2483	(11.7301)	-38.4769	73.3038	399
Urban population density	51.1113	(233.5605)	0.8544	3918.803	399
Rural population density	9.4345	(10.9149)	0	192.9066	399

Source: Authors' calculation based on data from the ICMS-E website http://www.icmsecologico.org.br/ and the IPEA website http://www.ipeadata.gov.br/. Monetary variables are taken in constant values (2000R$).

7.4. Creation of CUs over time

Figure 4: 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.

Table 3: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.
Municipal CU	1,171.67	3,665.87	1.4	22,76
Ratio of Municipal CU on total area	0.02	0.06	0	0.22
N		66		
Federal and state CU	10,030.03	24,534.67	1.72	213,265.20
Ratio of Federal and state CU on total area	0.11	0.19	0	0.99
N		165		

Notes : Conservation Units (CU) are measured in hectares, for the year 2010.

8. Tables

Table 4: Spatial interactions and MCF

	Dependent variable : MCF 2010			
n=1000, m=1				
Variable	Coefficient	*Direct*	*Indirect*	*Total*
ρ	-0.007961**			
	(0.015)			
MCF2000	2.147355***	2.159819***	-0.017943**	2.141876***
	(0.000)	(0.000)	(0.036)	(0.000)
FED2010	0.046348	0.04671	-0.000395	0.046315
	(0.408)	(0.417)	(0.502)	(0.417)
pop	-0.000087	-0.000099	0.000001	-0.000098
	(0.732)	(0.718)	(0.724)	(0.718)
agr	-0.120156***	-0.121699***	0.001038*	-0.120661***
	(0.000)	(0.000)	(0.071)	(0.000)
ind	-0.045715	-0.046228	0.0004	-0.045827
	(0.130)	(0.129)	(0.273)	(0.129)
inc	0.007792	0.007482	-0.000067	0.007415
	(0.763)	(0.773)	(0.790)	(0.773)
incsq	-0.002343	-0.00224	0.00002	-0.00222
	(0.699)	(0.714)	(0.744)	(0.714)
rur	-0.000506	-0.000507	0.000004	-0.000503
	(0.193)	(0.212)	(0.317)	(0.212)
urb	-0.000005	-0.000005	-0.000000	-0.000005
	(0.738)	(0.725)	(0.739)	(0.725)
Curitiba	-0.22267***	-0.223891***	0.001851*	-0.22204***
	(0.004)	(0.004)	(0.080)	(0.004)
intercept	-0.033999			
	(0.277)			
μ_r	yes			

*Notes: ***=significant at the 1 percent level, **=significant at the 5 percent level, *=significant at the 10 percent level. p-values associated to the reported coefficients are in parentheses. n correspond to the number of draws and m to the number of steps in the gibbs sampler.*

Table 5: Spatial interactions and BCC

	Dependent variable : BCC in 2010			
n=1000, m=1				
Variable	Coefficient	*Direct*	*Indirect*	*Total*
ρ	-0.015591**			
	(0.049)			
ratiom2000	2.496689***	2.50393***	-0.042608*	2.461322***
	(0.000)	(0.000)	(0.055)	(0.000)
ratioFED2010	0.002393	0.001981	-0.000046	0.001935
	(0.917)	(0.930)	(0.920)	(0.931)
pop	-0.000238	-0.000225	0.000004	-0.000221
	(0.424)	(0.448)	(0.532)	(0.447)
agr	-0.158445***	-0.157292***	0.002696*	-0.154596***
	(0.000)	(0.000)	(0.080)	(0.000)
ind	-0.06142**	-0.059479**	0.001014	-0.058464**
	(0.039)	(0.049)	(0.204)	(0.049)
inc	-0.00736	-0.009311	0.000168	-0.009144
	(0.781)	(0.730)	(0.743)	(0.731)
incsq	0.002291	0.002695	-0.00005	0.002646
	(0.720)	(0.676)	(0.686)	(0.677)
rur	-0.000265	-0.000301	0.000004	-0.000296
	(0.448)	(0.417)	(0.510)	(0.417)
urb	-0.00015***	-0.00015***	0.000003*	-0.000148***
	(0.000)	(0.000)	(0.065)	(0.000)
Curitiba	0.269058***	0.269791***	-0.004644*	0.265147***
	(0.000)	(0.000)	(0.089)	(0.000)
intercept	0.033778			
	(0.310)			
μ_r	yes			

*Notes: ***=significant at the 1 percent level, **=significant at the 5 percent level, *=significant at the 10 percent level. p-values associated to the reported coefficients are in parentheses. n correspond to the number of draws and m to the number of steps in the gibbs sampler.*

Table 6: Consistency tests

Dependent variable : MCF 2010						
m=	1		10		20	
n=	1000	10000	1000	10000	1000	10000
Variable						
ρ	-0.007961**	-0.005395**	-0.0093**	-0.00786**	-0.009105***	-0.00481*
	(0.015)	(0.014)	(0.018)	(0.029)	(0.001)	(0.075)
MCF2000	2.147355***	2.083261***	2.0062***	2.03212***	2.035416***	2.095744***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FED2010	0.046348	0.048372	0.0476	0.049377	0.040812	0.042334
	(0.408)	(0.361)	(0.299)	(0.332)	(0.408)	(0.418)
pop	-0.000087	-0.000195	-0.000000	-0.000111	-0.000000	-0.000122
	(0.732)	(0.435)	(0.827)	(0.652)	(0.999)	(0.623)
agr	-0.120156***	-0.120498***	-0.0978***	-0.110865***	-0.103823***	-0.112345***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ind	-0.045715	-0.047154	-0.0404	-0.044297	-0.047554*	-0.043165
	(0.130)	(0.101)	(0.106)	(0.106)	(0.068)	(0.127)
inc	0.007792	0.009978	0.0067	0.009938	0.012694	0.009026
	(0.763)	(0.711)	(0.776)	(0.697)	(0.593)	(0.723)
incsq	-0.002343	-0.00256	-0.0023	-0.002748	-0.003612	-0.002489
	(0.699)	(0.681)	(0.675)	(0.646)	(0.517)	(0.680)
rur	-0.000506	-0.00033	-0.0005	-0.000368	-0.000469	-0.000372
	(0.193)	(0.310)	(0.210)	(0.279)	(0.174)	(0.305)
urb	-0.000005	-0.000005	-0.000000	-0.000005	-0.000006	-0.000005
	(0.738)	(0.697)	(0.686)	(0.714)	(0.626)	(0.709)
Curitiba	-0.22267***	-0.208601***	-0.2005***	-0.20258***	-0.200199***	-0.211293***
	(0.004)	(0.005)	(0.001)	(0.003)	(0.002)	(0.004)
intercept	-0.033999	-0.028195	-0.0258	-0.036568	-0.029702	-0.028634
	(0.277)	(0.424)	(0.373)	(0.266)	(0.360)	(0.395)
μ_r	yes					

*Notes: ***=significant at the 1 percent level, **=significant at the 5 percent level, *=significant at the 10 percent level. p-values associated to the reported coefficients are in parentheses.* n *correspond to the number of draws and* m *to the number of steps in the gibbs sampler.*