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Municipal Responses to Ecological Fiscal Transfers in Brazil: A microeconometric panel data approach

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ABSTRACT
Ecological fiscal transfers in Brazil, the so-called ICMS-Ecológico or ICMS-E, redistribute part of the state-level value-added tax revenues on the basis of ecological indicators to local governments. We analyze whether the introduction of this economic instrument in a state offers incentives to municipal responses in terms of further protected area (PA) designation. We provide a microeconomic model for the functioning of ICMS-E and test the derived hypothesis empirically. Employing an econometric analysis on panel data for two decades we estimate the correlation of the introduction of ICMS-E in Brazilian states with PA coverage. We find that the introduction of ICMS-E correlates with a higher average PA share. While the introduction of ICMS-E schemes may be a compensation for a high share of federal and state PA, we also find an incentive effect for municipalities to designate additional PA.

Keywords: conservation incentives; ecological fiscal transfers; economic instruments; fiscal federalism; ICMS-Ecológico; policy evaluation

Introduction

AGAINST THE BACKDROP OF BIODIVERSITY AND ECOSYSTEM SERVICE LOSS, SUITABLE AND EFFECTIVE POLICY INSTRUMENTS THAT COULD help to halt this trend are of great interest to meet the Aichi biodiversity targets of the Convention on Biological Diversity's Strategic Plan to 2020 (CBD, 2010). Ecological fiscal transfers (EFT) could be one such instrument. Intergovernmental fiscal transfers redistribute tax revenue from higher to lower levels of government, based on a number of different indicators such as population or area of the relevant jurisdiction. EFT redistribute a share of these public revenues according to nature conservation or other environmental indicators. Several authors see EFT as an instrument that could potentially incentivize greater nature conservation (Grieg-Gran, 2000; Loureiro, 2002; May *et al.*, 2002; Ring, 2008a; Young, 2005).

Since the pioneering implementation in the state of Paraná in 1991, a number of Brazilian states have adopted EFT from the state to the municipal level in the so called 'Ecological Value-Added Tax' (ICMS-Ecológico, ICMS-E for short). To date 17 Brazilian states have implemented EFT schemes, of which 16 have included explicit indicators

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relating to protected areas (PA) in the criteria for tax revenue distribution. This setting provides an opportunity to analyze the effectiveness of the instrument with regard to its economic incentive effect for designating additional PA.

The benefits of designated PA are mainly public in nature. However, the designation of further PA incurs opportunity costs. These are mainly costs to private actors, such as land-use restrictions for agriculture, infrastructure, housing and industry. However, they also lead to lower tax revenues for public jurisdictions and incur management costs for administrating bodies. This constitutes a problem of collective action and requires that adequate institutions be put in place, defining who should be responsible for the required policies and who should bear their costs. The study of fiscal federalism analyzes how public functions and finance are and should best be distributed among different government levels in federal systems (Bird and Smart, 2002; Boadway and Shah, 2009; Musgrave, 1959; Oates, 1972, 2005). The principle of 'fiscal equivalence' basically states that those who receive benefits of a policy should also pay for the related costs (Olson, 1969).[1] In the case of positive external effects beyond the boundaries of a jurisdiction that is paying for the provision of the relevant public good, this would require compensation payments. To address the issue, fiscal transfers are an adequate instrument to internalize spill-over effects (Bird and Smart, 2002; Boadway and Shah, 2009; Dahlby, 1996; Dur and Staal, 2008).

According to the Brazilian constitution the value-added tax (ICMS) is levied by states (Constituição da República Federativa do Brasil de, 1988 Art. 155 II). A quarter of this relevant state revenue is allocated according to the derivation principle: it belongs to the municipalities that generated it (Constituição da República Federativa do Brasil de, 1988 Art. 158 IV). Of this quarter, 75 per cent must be distributed proportionally to the contribution of each municipality to the value added of the state. The remaining 25 per cent (6.25 per cent of the total) is redistributed to municipalities according to criteria established under state law (e.g. population or agricultural production) (Constituição da República Federativa do Brasil de, 1988 Art. 158 IV). The ecological fiscal transfers (*ICMS-E: Imposto sobre Circulação de Mercadorias e Serviços – Ecológico*) introduce ecological criteria to redistribute this share, for instance considering registered PA on municipal territory.

Differing from state to state, the share of the ecological indicator is up to 8 per cent of the municipal value-added tax revenue (2 per cent of total ICMS). The ICMS-E scheme was first implemented to reward municipalities for hosting (federal and state) PA; later on it was also thought to incentivize municipalities to designate additional municipal PA (Grieg-Gran, 2000; Loureiro, 2002; May *et al.*, 2002; Ring, 2008a).

The scheme has several interesting attributes: (i) it does not require any additional finance since it constitutes a change in the distribution of existing tax revenue – which is of particular interest due to the lack of conservation finance and overall budget constraints; (ii) it partly decentralizes the decision of where to protect nature, taking into account local preferences and benefiting from local knowledge (Sauquet *et al.*, 2014); (iii) it is seen as an incentive for nature conservation and may provide a greater supply of an underprovided public good (Droste, 2013; Grieg-Gran, 2000; May *et al.*, 2002; Ring, 2008a); (iv) it potentially benefits low income municipalities that would not receive much (value-added) tax revenue in the absence of the instrument (Grieg-Gran, 2000); (v) the transaction costs for implementing such a scheme are considerably low, since it represents only a rather marginal change in an existing fiscal transfer scheme (Ring, 2008a; Vogel, 1997).

EFT have recently gained quite some attention outside of Brazil. Portugal established a municipal EFT scheme in 2007 (Santos *et al.*, 2012). In France, there are compensation schemes for municipalities in core areas of national parks (Borie *et al.*, 2014). In Queensland, Australia, a multi-criteria analysis has been used for the allocation of environmental funds via fiscal transfers (Hajkowicz, 2007). For Germany, Switzerland, Indonesia and India, EFT schemes have been proposed and the consequences simulated (Czybulka and Luttmann, 2005; Irawan *et al.*, 2014; Köllner *et al.*, 2002; Kumar and Managi, 2009; Mumbunan, 2011; Perner and Thöne, 2007; Ring, 2002, 2008b; Schröter-Schlaack *et al.*, 2014). Farley *et al.* (2010) even suggest an adaptation to the global level. The studies for countries with implemented EFT schemes mainly focus on the institutional design of the instrument and provide limited empirical evidence of its effects on further PA designation. For Brazil, Sauquet *et al.* (2014) provide a first econometric analysis of the effects of the ICMS-E by analyzing strategic interaction among municipalities in the state

[1]This principle basically internalizes external effects of public policy. In the case of spill-over effects to other regions a more centralized government might be better suited to take account of the relevant public goods and services to avoid them being underprovided.

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of Paraná. The effectiveness of the socio-environmental ICMS in Pernambuco regarding social policies, namely education and health, has been studied by Da Silva Júnior and Sobral (2014) with a Markov chain simulation.

This paper aims to contribute to the literature with an econometric approach that analyzes the effectiveness of the instrument on the basis of the introduction of the ICMS-E in 17 Brazilian states over the last two decades. The research question is whether the ICMS-E offers an incentive toward a local level response in terms of additional municipal PA designations.

The econometric model estimates the correlation of introducing ICMS-E in Brazil with PA coverage in a panel data setting of all 27 Brazilian states from 1991 to 2009, controlling for socioeconomic and conservation policy variables. Hypothetically, municipalities are more inclined to increase their municipal-level PA or seek ways to attract federal or state designations of such PA if these become a source of income via EFT. The results will give insights about the functioning of the instrument and correlations of other variables with PA coverage, and provide lessons for the design of similar schemes.

The structure of the paper is as follows. The next section provides background information on the historical development and institutional details of ICMS-E schemes in Brazil. The third section briefly indicates the data source and gathering methods for the subsequent analysis. The fourth section presents a theoretical microeconomic model of the functioning of the instrument and describes the econometric model used to test our hypothesis generated from theory. The fifth section gives the result of the econometric analysis. The sixth section is a discussion of our findings and their limitations and relevance, followed by our conclusion in the seventh section.

Background

The first ICMS-E scheme was introduced in Paraná, after a number of municipalities with PA for biodiversity conservation or watershed protection areas on their territory exerted pressure on the state government in 1990 (Grieg-Gran, 2000). ICMS revenue was largely distributed among the municipalities that generated it, while opportunity costs of PA were not taken into account. Municipalities with PA faced restrictions on land use and these were perceived as constraints in terms of both development and tax revenue generation. The mayors of the affected municipalities hence argued that complying with such land-use restrictions was difficult and demanded compensation (Grieg-Gran, 2000). In response, the first EFT scheme, with a 5 per cent share of the valued-added tax revenue accounting for the existence of PA for biodiversity conservation and watershed protection (2.5 per cent each), was implemented in late 1991 by the front-runner Paraná. The rationale for the first scheme was basically compensation for opportunity costs but it was soon thought of as an instrument that could also incentivize nature conservation (Grieg-Gran, 2000; May *et al.*, 2002). After Paraná, São Paulo was the next state to introduce an EFT scheme in 1993 (with a relatively low ecological share of 0.5 per cent). Step by step other states followed and implemented similar EFT schemes, experimenting with different design options.

In some states the ICMS schemes incorporating environmental indicators are called socio-environmental ICMS (i.e. in Pernambuco and Ceará), and in the latter case it only refers to solid waste management. In Minas Gerais the law that includes the ICMS-E is officially called the 'Robin Hood Law', because it is designed to transfer tax revenues to poor regions and takes into account several social and environmental criteria; it was originally enacted in 1997 (Fundação João Pinheiro, 2014). The most commonly used method for determining the amount of EFT to be distributed to local governments largely builds on the pioneering example of Paraná (see Equations 1–3). An environmental index EI_i

$$\mathrm{EI}_i = \frac{\mathrm{MCF}_i}{\mathrm{SCF}} \tag{1}$$

is calculated as a ratio of municipality *i*'s protected area (PA) portion of total municipal area (*M*), the municipal conservation factor

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$$\mathrm{MCF}_i = \frac{\mathrm{PA}_i}{M_i} \tag{2}$$

over the sum of all n municipalities' ratios, the state conservation factor

$$\mathrm{SCF} = \sum_{i=1}^{n} \mathrm{MCF}_i \tag{3}$$

while weighting different PA_i categories according to their contribution to conservation goals (cf. Loureiro, 2002; Loureiro *et al.*, 2008; Ring, 2008a; Sauquet *et al.*, 2014). As can be seen in Table 1, the institutional design of the ICMS-E schemes varies among states (cf. The Nature Conservancy, 2014).

Very important institutional features for the functioning of ICMS-E schemes are the specifics of the Brazilian conservation law and corresponding competencies of different government levels (cf. May *et al.*, 2012). The National System of Protected Areas (SNUC) recognizes 12 different types of PA category, which roughly correspond to the PA category classification of the International Union for Conservation of Nature (IUCN). They are furthermore differentiated within two main groups: strictly protected areas (*proteção integral*), which in general do not allow private land ownership and land use, and less restrictive ones (*uso sustentável*), which permit sustainable land use and private property. While the first category is essential to protect endangered species and ecosystems and provides services only supplied by healthy and intact ecosystems, the latter category potentially increases the sustainability of, e.g., agricultural practices. A particular characteristic of the Brazilian system is that all three government levels have legislative powers to designate all 12 PA types on their own. Even the stricter categories such as 'parks' can be designated not just by the federal government but also by state and municipal governments. Furthermore, the SNUC devises rules for the voluntary designation of publicly recognized and legally binding PA on private land.

In 2014, a total of about 18 per cent of terrestrial area in Brazil was included under conservation statutes, which comprises about 8.8 per cent national PA, 8.9 per cent state PA and 0.3 per cent municipal PA (Ministério do Meio Ambiente, 2014a, see also next section for data collection methods). Although the latter seems insignificant, the huge spatial extent of Brazil makes 0.3 per cent equivalent to the area of Belgium. This is to say, compared with national and state conservation efforts, municipal conservation activities seem comparatively small. They may, however, engage local actors and their knowledge and thus protect viable spots for local ecosystem functioning and biodiversity protection (Grieg-Gran, 2000). Municipal PA are therefore not the most important ones from a large-scale contiguous conservation perspective, but they constitute an important and decentralized complement to the national and state governed PA systems.

Regarding the calculation of the ICMS-E, all different PA categories enter the computation of ecological fiscal transfers, but they may have different weights in states with different ICMS-E designs. Table 1 summarizes the shares and indicators of the different ICMS-E schemes in place.

Data Collection

This study builds on the analysis of legal documents regarding the introduction of state-level ICMS-E schemes and is based on data for PA coverage, socio-economic data of the share of value added by different sectors, population density and per capita GDP. The Nature Conservancy website (2014) on the ICMS-E schemes provides background information and links to the legal documents in which the schemes are specified. We have collected data on both the original state law that basically prepares the legal grounds and on the implementing decrees that actually enact the schemes.

The national cadaster of conservation units (CNUC) of the Brazilian Ministry of the Environment (Ministério do Meio Ambiente, 2014a) provides data on PA recognized within the national system of conservation units (SNUC) with respect to time of enactment, area and related legal acts. We have furthermore consulted the state environmental secretariats' websites to complement the national cadaster, because the latter relies on input from the governing bodies and apparently is not entirely complete, i.e. with regard to municipal PA. We only

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Brazilian states	Year of first legislation	Year of legal enactment	Share of value-added tax for conservation efforts	Ecological indicators
Acre (AC)	2004	2010	1% (2010), 2% (2011), 3% (2012), 4% (2013), 5% (from 2014)	PA (areas recognized in the national PA system and/or state system)
Alagoas (AL)	–	–	–	–
Amapá (AP)	1996	1998	1.40%	PA
Amazonas (AM)	–	–	–	–
Bahia (BA)	–	–	–	–
Ceará (CE)	2007	2008	0% (only solid waste management is considered)	waste management
Espírito Santo (ES)	–	–	–	–
Federal District of Brasília (DF)	–	–	–	–
Goiás (GO)	2011	2012	up to 5% in form of a composite indicator (1.25 in 2012, 2.5% in 2013, 3.75% in 2014, 5% in 2015	sustainable development plans (PA, waste management, environmental education, reduced deforestation, reduced forest fires, watershed protection etc.)
Maranhão (MA)	–	–	–	–
Mato Grosso (MT)	2000	2002	5%	PA and indigenous lands
Mato Grosso do Sul (MS)	1994	2002	2% (2002), 3.5% (2003), 5% (2004) for various environmental criteria	PA, indigenous lands, waste management plans
Minas Gerais (MG)	1995	1997	PAs 1 of 3 environmental criteria 0.5% (2010), 0.45% from 2011	PA per municipal area, conservation factor (~PA category) and conservation quality factors
Pará (PA)	2012	2014	for all environmental criteria 2% (2012), 4% (2013), 6% (2014), 8% (from 2015)	PA extent, avoided deforestation, registered rural lands etc.
Paraíba (PB)	2011	not yet	5%	PA
Paraná (PR)	1991	1992	2.5% for PAs for biodiversity conservation and 2.5% for PAs for watershed	PA, PA category, and variation of conservation quality
Pernambuco (PE)	2000	2001	1%	PA share per municipal area, their category and degree of conservation
Piauí (PI)	2008	2009	overall environmental criteria are 1.5% in 2009, 3.5% in 2010, 5% from 2011 (PAs 1 out of 9 environmental criteria)	waste management, watershed protection, reducing deforestation, pollution control, PAs etc.
Rio de Janeiro (RJ)	2007	2009	1% (2009), 1.8% (2010), 2.5% from 2011	PA, water quality, waste management, plus an extra for designation of municipal PAs
Rio Grande do Norte (RN)	–	–	–	–
Rio Grande do Sul (RS)	1997	1998	7% (for a composite indicator)	municipal area, 3 times PA, indigenous lands, inundated lands

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Brazilian states	Year of first legislation	Year of legal enactment	Share of value-added tax for conservation efforts	Ecological indicators
Rondônia (RO)	1996	2003	5%	share of PA per municipal area, number of PA and past year total PA area
Roraima (RR)	–	–	–	–
Santa Catarina (SC)	–	–	–	–
São Paulo (SP)	1993	1994	0.5% only accounting for state PA	PA and PA category
Sergipe (SE)	–	–	–	–
Tocantins (TO)	2002	2007	3.5%	PA and indigenous land (+ another 3.5 for watershed protections, waste management etc.)

Table 1. Introduction time and design of ICMS-E schemes in Brazilian states. Source: authors' elaboration based on The Nature Conservancy (2014) and legislative acts

complemented the national cadaster data when (a) the category of additional PA complies with the national system of conservation areas, (b) there was data on the area and (c) legal acts were indicated. We then used the i3Geo software of the Brazilian Government (Ministério do Meio Ambiente, 2014b) to calculate the terrestrial PA size. We excluded marine PA, since they are not included in any ICMS-E scheme and are furthermore large in area. Where we identified a spatial overlap in the available geo-referenced data, we computed the overlap free PA share with the following hierarchy: (i) if there is both strict protection and sustainable use area we only accounted for the first; (ii) if there are two PA of the same category from different government levels we only accounted for the highest government level PA. We thereby compiled a data set of the development of PA at different government levels and their share of state territory by year among Brazilian states.

The governmental Institute for Applied Economic Research (IPEA) provides data on the value added by agriculture and industry, on estimated population density and on GDP per capita of the Brazilian states for 1991–2009 (Instituto de Pesquisa Econômica Aplicada – IPEA, 2014). All this data was gathered in a panel data set for the Brazilian states.[2]

Theoretical and Econometric Models

Theoretical Model

The theoretical model of the effects of fiscal transfers is based on the work of Boadway and Shah (2009, Chapter 9) and represents a simplistic microeconomic model of a government body's spending behavior receiving a fiscal transfer (see Figure 1). The model substantiates the derivation of hypotheses that are tested in the empirical part (next sub-section and next section).

The ICMS-E in Brazil is a general budget support based on the share of PA in the municipal territory. When a government body receives such an unconditional general purpose transfer there are no obligations for a particular spending behavior, i.e. they are not ear-marked for specific purposes. Let us consider this in a two-good model world. Let Y denote a composite non-nature conservation public good or service and X a nature conservation public good or service that can both be supplied by a government body by some sort of public expenditure. Let there be a

[2]The dataset can be downloaded at https://github.com/NilsDroste/EFT-BR

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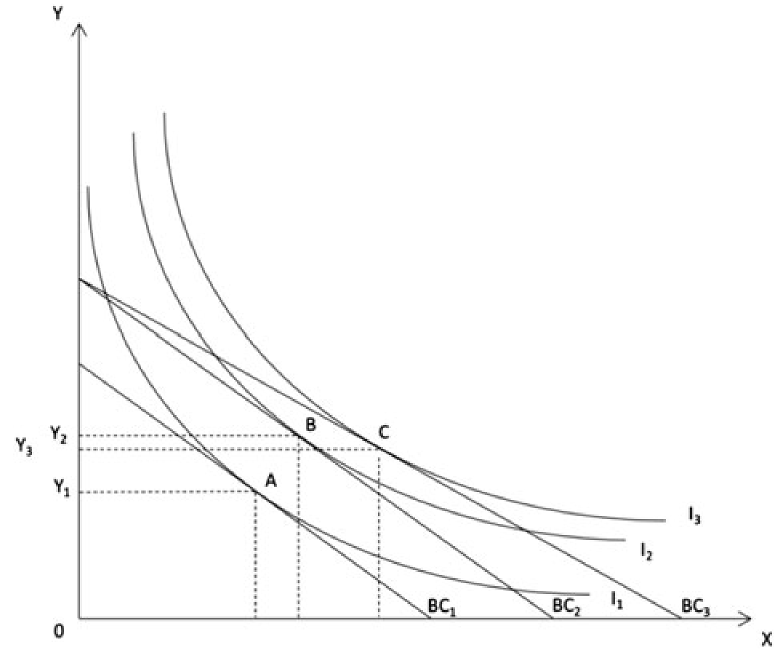

Figure 1. Government spending behavior after introduction of fiscal transfers
Source: authors' work adapted from Boadway and Shah (2009, Chapter 9)

budget constraint BC representing the amount that can be spent based on relative prices and a utility indifference curve *I* based on the utility gained by the satisfaction of preferences and the marginal rate of substitution among these two goods. A (boundedly) rational government would maximize its utility where the marginal rate of substitution equals the budget constraint (see Point A in Figure 1). A general purpose transfer to this government shifts the budget constraint outwards, e.g. from BC_1 to BC_2. The government's budget increases with the transfer, as does spending on both goods. Now, the ICMS-E is a general purpose transfer based on a particular public service, namely the existence of PA in the territory of the municipality. This represents a price change in terms of relative prices, since every unit of PA will be rewarded and a PA designation therefore has lower opportunity costs than without the instrument. In our model world this can be seen as the price change (BC_2 to BC_3). The spending effect of such a shift will reduce spending on Y (Y_2 to Y_3) and increase spending on X. Comparing the initial state without the fiscal transfer (Point A) and the state with fiscal transfers (Point C), spending on both goods increases. The effect of the fiscal transfers can be decomposed into two partial effects, namely the outward shift of the budget constraint and the price change. The empirical outcomes *inter alia* depend on the real structure in preferences, relative prices, marginal rates of substitution and extent of rationality applied. Real world outcomes may be more complex than this simplified model suggests.[3]

Nevertheless, the hypothesis that we derive from this model is that if there is an ICMS-E scheme in place municipal governments receiving the EFT will increase spending on both non-nature conservation and nature conservation. We suppose that such an increased spending on nature conservation should to some extent be reflected in an increased share of PA in the municipal territory, because they constitute a source of additional income. However, EFT might also decrease the municipal resistance to accepting a state or federal PA on municipal territory due to the 'price effect' of lower opportunity costs for hosting PA. Therefore, we hypothesize

[3]We recognize the possibility of a strategic interaction: the probability of a municipality receiving extra income through conservation action is lowered by the entrance of other municipalities' conservation action. Nevertheless, the amount of money distributed through the ICMS-E system also depends on the performance of the economic system, since ICMS-E is a share of the total value-added tax revenue. In the case of economic growth more money will be distributed according to PA shares. Strategic conservation interactions have partly been addressed by Sauquet *et al*. (2014), but to our knowledge an analysis of thresholds at which a municipality does not receive any further transfer when designating an additional PA has not yet been conducted and remains for future research.

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that in states and years where there is an ICMS-E scheme in place a higher (municipal) share of PA should be observed.

Econometric Model

The econometric model estimates the correlation of ICMS-E schemes with nature conservation area share, with random effect regressions controlling for other conservation instruments, biomes and socio-economic variables for land-use pressure such as the share of value added by agriculture and industry, population density and GDP per capita. The general structure of the regression is as outlined in Equation 4.

$$\begin{aligned}\ln(\mathrm{PA})_{it} = \beta_0 + \beta_1 \mathrm{icms\_e}_{it} + \beta_2 \ln(\mathrm{agr})_{it} + \beta_3 \ln(\mathrm{ind})_{it} + \beta_4 \ln(\mathrm{pop})_{it} + \beta_5 \ln(\mathrm{inc})_{it} + \beta_6 \mathrm{arpa}_{it} + \beta_7 \ln(\mathrm{oPA})_{it} \\ + \beta_8 \mathrm{biome}_{ji} + \beta_9 \mathrm{year} + \beta_{10} \mathrm{int}_{it} + \mu_i + \varepsilon_{it} \qquad (4)\end{aligned}$$

where $i = 1, ..., n$ indexes the Brazilian state, $t = 1, ..., T$ indexes years and $j = 1, ..., k$ indexes the biomes. PA_{it} is the share of PA in year t of total territory of state i in per cent, which will either be PA total (PAtot), federal (PAfed), state (PAsta) or municipal (PAmun) PA share.[4] The policy variable icms_e is a dummy with the value of 1 in the case of an existing ICMS-E scheme in state i in year t and 0 otherwise. The socio-economic controls for states i and years t, agriculture agr and industry ind, are the per cent shares of total value added by these two sectors (at constant prices of year 2000)[5]; pop is population density in inhabitants per square kilometer, and inc is GDP per capita at constant prices of year 2000.[6] arpa is a dummy variable for the ARPA policy,[7] which supports PA designations in the Amazon with a value of 1 in the case of implementation in state i in year t and 0 otherwise. Other PA oPA is only included when regressing federal, state or municipal PA on the explanatory variables and consists of a vector of the other two PA share variables, e.g. federal level PA share PAfed and state level PA share PAsta in the case of a regression of municipal PA share PAmun on the controls. The vector of dummy variables biome indicates a minimum 5 per cent share of any of the six different biomes of Brazil on state i's area (IBGE and Ministério do Meio Ambiente, 2004): Amazon (ama), Cerrado (cer), Caatinga (caa), Atlantic Forest (mat), Pantanal (pan) and Pampa (pam) – which can be overlapping if a state has different biomes.[8] The year variable is included in individual random effect regressions to detrend the development of PA designations. Variable int stands for a vector of interaction variables of the above-mentioned icms_e and the socio-economic control variables. The error terms are μ_i, individual error term, and ε_{it}, idiosyncratic error term – making it a one-way (individual specific) effect regression (Croissant and Millo, 2008). The panel is balanced with $n = 27$ for the 26 Brazilian states and the Federal District of Brasilia, $T = 19$ for the years 1991–2009 and $N = 513$ observations in total. Hypothetically, states may have an incentive to enhance PA coverage if PA become a source of income by the EFT scheme – hence, we should be able to observe a correlation of ICMS-E with PA coverage (H_1). The null-hypothesis (H_0) is that an increase in budget due to ICMS-E does not correlate with PA coverage – which could mean that the additional ICMS-E income has very likely been spent on different non-nature conservation public services.

The regressions are computed with the **plm** package (Croissant and Millo, 2008) in **R** (R Development Core Team, 2013) with random effect regressions to control for unobserved individual heterogeneity such as state

[4]In the case of state and municipal PA there are reasonable zeros in the data. We added a constant c of half the minimum observed value for each state and municipal data to allow for log transformation.
[5]We originally included both the industry and the service sector in the model. However, the logarithms of the service sector and the industry sector value-added variables are strongly correlated, with a coefficient of 0.81. In order to avoid multicollinearity we only included the industry variable in the regression.
[6]The data was given in year 2010 prices and has been recalculated with consumer price indices (IBGE, 2015).
[7]ARPA means the Amazon Region Protected Areas Programme, which collaborates with state and local governments in creating new PA in the Amazon biome, and came into force in 2002.
[8]The value of the biome dummies is set according to the following categorization (see Table 1 for abbreviations of the states): RO, ama; AC, ama; AM, ama; RR, ama; PA, ama; AP, ama; TO, ama&cer; MA, ama&cer; PI, cer&caa; CE, caa; RN, caa&mat; PB, caa&mat; PE, caa&mat; AL, caa&mat; SE, caa&mat; BA, cer,caa&mat; MG, cer&mat; ES, mat; RJ, mat; SP, cer&mat; PR, mat; SC, mat; RS, mat&pam; MS, cer,mat&pan; MT, ama, cer&pan; GO, cer; DF, cer.

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preferences for nature conservation (cf. Wooldridge, 2010, chapters 10, 11). Standard errors are computed with covariance matrix estimators robust to heteroskedasticity, serial and spatial (cross-sectional) correlation, with a maximum lag window of $m(T) = 2$ (Driscoll and Kraay, 1998; Millo, 2016)[9] and heteroskedasticity consistent covariance estimation type HC3, which gives less weight to influential observations (Long and Ervin, 2000; Zeileis, 2004).[10]

Results

We estimate the effect of ICMS-E schemes and several political, socio-economic and geographic indicators on the average PA share of 26 Brazilian states plus the Federal District for the years 1991–2009. Summary statistics are provided in the appendix. For both regressions of total PA share and municipal level PA share (Tables 2 and 3), we start with a simple model including the socio-economic control variables (Model 1) in which we add-in further control variables for the biomes (Model 2), the year variable (Model 3), and interaction terms (Model 4).

We find a significant and positive correlation of icms_e, significant and negative correlation of ln(agr) and a significant positive correlation of ln(inc) with the logarithm of PA share ln(PAtot) (see Table 2). We furthermore find structural differences of how much nature is conserved among the biomes of Brazil. As soon as the biome dummies are included the explanatory power of the model increases (Model 2). The numeric year variable is positively and significantly correlated and its interaction term with icms_e is negatively and significantly correlated (Model 3). Furthermore, ln(ind) has a positive and significant correlation when year and its interaction term are included (Models 3 and 4). An inclusion of further interaction terms of icms_e with socio-economic controls does not yield any further significant correlation or increase in explanatory power (Model 4).

Regarding the effect of the ICMS-E on municipal-level PA designation, we find a significant and positive correlation of icms_e, a positive and significant correlation of ln(agr) and ln(pop) and a negative significant correlation of ln(ind) with the municipal PA share (Models 1 and 2 in Table 3). We furthermore find a positive significant correlation of the natural logarithm of federal level PA share ln(fed). Including the time trend does not change much (Model 3). Once the interactions of icms_e with other socio-economic controls are included the picture becomes more complex: e.g., both the time trend and its interaction term show a significant and positive correlation; the interactions with ln(agr), ln(pop) and ln(fed) are significant and negative (Model 4).

Discussion

First of all, there are some methodological remarks to consider. Generally, the panel data setting with individual effects would allow for estimating causal effects, or the 'average treatment effect on the treated' with Brazilian states self-selecting into 'treatment' of implementing ICMS-E schemes compared to an average of states without such a scheme (see, e.g., Wooldridge, 2010, Chapter 18 for a discussion of causal effects estimations). This

[9]Given a rejection of the null hypothesis of a unit root at the 5 per cent significance level with a cross-sectionally augmented Im–Pesaran–Shin unit-root test for single time series of panel data (Im *et al.*, 2003, Pesaran, 2007), the corresponding order of integration for each of the logarithmized non-stationary time series is given in parenthesis: PAtot (1), PAfed (1), PAsta (>2), PAmun (2), agr (1), ind (1), pop (1), inc (1). In contrast, a panel covariate augmented Dickey–Fuller test on the entire panel (Demetrescu *et al.*, 2006; Kleiber and Lupi, 2011) rejects the null at 1 per cent significance levels. However, since we are rather interested in long-term effects, a first-differencing approach – which would generally be a way to go for non-stationary time series – does not seem appropriate. As has been shown (Pesaran and Smith, 1995; Phillips and Moon, 1999) long-run relationships can consistently be estimated with (quasi-)demeaned data through fixed or random effects and detrended data, given cross-sectional independence. Therefore, in our case of cross-sectional dependence, a robust estimation is a must. The Driscoll and Kraay (1998) covariance matrix estimation employed accounts for auto- and cross-sectional correlations and even for spatial dependence. We therefore consider it a suitable approach for handling the various sources of dependencies across estimates.

[10]Both the R code and the data required to reproduce the results presented in this paper can be found at https://github.com/NilsDroste/EFT-BR

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Dependent variable: ln of total protected area share PAtot as percentage of total area				
Model: Variables	1	2	3	4
icms_e	0.549** (0.223)	0.512*** (0.105)	1.146*** (0.285)	2.490 (1.525)
ln(agr)	−0.372*** (0.113)	−0.294*** (0.081)	−0.202*** (0.072)	−0.200*** (0.077)
ln(ind)	−0.087 (0.119)	−0.018 (0.127)	0.217* (0.114)	0.235** (0.103)
ln(pop)	0.199*** (0.052)	0.643*** (0.154)	−0.079 (0.122)	−0.058 (0.144)
ln(inc)	2.164*** (0.532)	2.513*** (0.240)	0.891* (0.486)	0.884** (0.445)
arpa	0.220 (0.217)	−0.033 (0.129)	−0.154 (0.161)	−0.202 (0.222)
ama		3.251*** (0.507)	1.276* (0.731)	1.229* (0.745)
cer		0.116 (0.359)	0.448*** (0.120)	0.480* (0.258)
caa		1.864*** (0.421)	−0.104 (0.471)	−0.210 (0.615)
mat		−0.859** (0.372)	−0.685*** (0.181)	−0.680*** (0.194)
pan		−1.431** (0.595)	−1.929 (1.976)	−1.976 (2.329)
pam		−1.035 (0.771)	−0.713 (0.531)	−0.600 (0.400)
year			0.090*** (0.011)	0.092*** (0.011)
icms_e*year			−0.063*** (0.011)	−0.055*** (0.017)
icms_e*ln(agr)				0.142 (0.129)
icms_e*ln(ind)				−0.143 (0.444)
icms_e*ln(pop)				0.065 (0.124)
icms_e*ln(inc)				−0.865 (0.614)
Intercept	−1.461 (1.795)	−4.660*** (0.885)	−0.845 (1.374)	−0.909 (1.187)
Effects	individual re	individual re	individual re	individual re
Adj. R^2	0.37	0.45	0.56	0.57

Table 2. Overall protected area share and ICMS-E
The panel data sample is balanced with $n = 27$, $T = 19$, $N = 513$. Robust standard errors are reported in parentheses. Individual coefficients are indicated with *10%, **5% or ***1% significance levels. Models use random effects (re) specifications.

analysis of the IMCS-E effects, however, is among the very first of its kind and there are no reference models neither on causal factors for protected area designation nor on the causal effects of policies such as ICMS-E schemes on protected area coverage (except to some extent Sauquet *et al.* 2014 who focus on spatial interaction). We therefore tend to be cautious on the issue and speak of an observed correlation rather than a causal effect.

With regard to the coefficients and their magnitude we also tend to be cautious and will not elaborate too much on the strength of the marginal effects[11] of introducing ICMS-E schemes, because we know that there is data missing for municipal PA and this may bias estimations (see below for further limitations). For the purpose of illustrating the apparent functioning of the ICMS-E schemes we mainly focus on the direction of correlations, that is to say the signs and significance. Figure 2 furthermore provides an overview about interactions which we discuss for some examples found in the data in more detail. Consider the ICMS-E dummy variable D in Figure 2. If there is an interaction with IMCS-E this means that the intercept will be $\beta_0+\beta_1$ and the slope $\beta_2+\beta_4$, and for the cases where there is no ICMS-E it will be β_0 and β_2, respectively. In the following we discuss both the overall PA share and municipal PA share regressions as well as some overarching issues such as reverse causality and inferences.

[11]When both dependent and independent variables are log transformed, the coefficients can be interpreted as a percentage change, say a 1% change in agr corresponds to a $[(1.01)^{\beta_1}-1]\times 100$ percentage change in PAtot holding everything else constant, for PAtot $=\beta_0+\beta_1\text{agr}+u_i$. Note, however, that coefficients of binary variables have to be interpreted as $100[\exp(\hat{c}-0.5\hat{v}(\hat{c}))-1]$, where $\hat{v}(\hat{c})$ is the estimated variance of $\hat{c}$ or the square of the standard error (Giles, 2011; Kennedy, 1981).

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Dependent variable: ln of municipal protected area share as percentage of total area				
Model: Variables	1	2	3	4
icms_e	1.332*** (0.189)	1.275*** (0.177)	1.095** (0.486)	4.834 (5.637)
ln(agr)	0.846*** (0.232)	0.924*** (0.229)	1.014*** (0.257)	0.856*** (0.186)
ln(ind)	−1.326*** (0.372)	−1.524*** (0.405)	−1.324*** (0.501)	−1.188*** (0.369)
ln(pop)	2.000*** (0.498)	2.465*** (0.615)	1.955*** (0.553)	1.846*** (0.670)
ln(inc)	2.536*** (0.706)	2.115*** (0.772)	1.205* (0.717)	0.092 (0.531)
ln(PAfed)	0.648*** (0.193)	0.662*** (0.197)	0.596*** (0.195)	0.614*** (0.151)
ln(PAsta)	0.116 (0.101)	0.125 (0.108)	0.095 (0.134)	0.079 (0.129)
arpa	0.512 (0.334)	0.388 (0.372)	0.368 (0.387)	1.243** (0.574)
ama		−4.877* (2.486)	−6.177*** (1.695)	−5.951*** (1.094)
cer		−5.344*** (1.164)	−5.074*** (1.310)	−4.713*** (0.542)
caa		−0.763 (1.944)	−2.089 (1.556)	−3.274*** (1.174)
mat		−3.697* (2.145)	−3.664* (2.163)	−2.274 (1.411)
pan		4.956 (6.545)	4.314 (7.358)	2.778 (2.586)
pam		−1.476 (2.562)	−1.398 (2.727)	−3.268 (2.578)
year			0.054 (0.046)	0.061* (0.036)
icms_e*year			0.008 (0.030)	0.089*** (0.025)
icms_e*ln(agr)				−0.663*** (0.240)
icms_e*ln(ind)				0.162 (1.081)
icms_e*ln(pop)				−1.006** (0.461)
icms_e*ln(inc)				1.548 (1.670)
icms_e*ln(PAfed)				−2.437*** (0.567)
icms_e*ln(PAsta)				−0.356 (0.307)
Intercept	−14.919*** (2.521)	−9.591** (4.586)	−7.292** (3.541)	−5.853** (2.441)
Effects	individual re	individual re	individual re	individual re
Adj. R^2	0.35	0.37	0.37	0.43

Table 3. Municipal level protected area share and ICMS-E
The panel data sample is balanced with n = 27, T = 19, N = 513. Robust standard errors are reported in parentheses. Individual coefficients are indicated with *10%, **5% or ***1% significance levels. Models use random effects (re) specifications.

Overall PA Share Regressions

We find a positive and significant correlation of the existence of an ICMS-E scheme with overall PA share among Brazilian states for the years 1991–2009. This means on average there is a higher PA ratio in states and years with an ICMS-E scheme in place. Furthermore, we find one significant correlation in all regressions: a positive correlation of PA coverage with GDP per capita. This means that, on average, where and when there is a higher per capita income more PA are observed. A potential explanation may be that nature conservation is not the first thing to think about when there is no or little income available. Once basic needs are covered a healthy environment becomes more important.

Municipal PA Share Regressions

On the municipal level the regressions reveal complex patterns. We find a positive and significant correlation of the share of value added by agriculture, population density and GDP per capita, and a negative significant correlation of the share of value added by industry with the municipal PA share. On average, the share of value added by industry constitutes the highest opportunity costs for municipal PA designation. Furthermore, municipalities with high population density more often designate PA. When interaction terms with socio-economic controls are included

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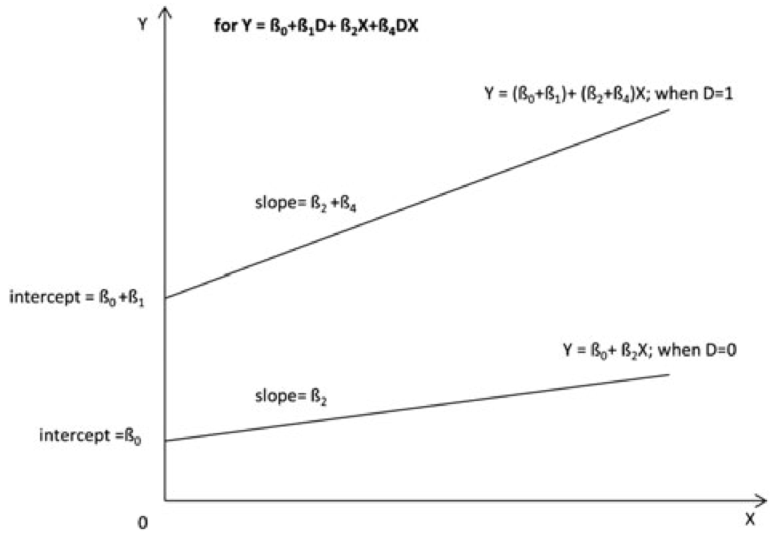

Figure 2. The interaction of the ICMS-E dummy variable *D* with a continuous variable
Source: authors' work adapted from Brambor (2005)

the coefficients of the ICMS-E interaction with both agriculture and population density are significant and negative. Thus, where there is an ICMS-E scheme in place the direction of the correlation may change. Considering Figure 2 one can interpret the correlation of agriculture with municipal PA share ($\beta_{\ln(agr)} = 0.856$) where there is an ICMS-E scheme ($\beta_{icms\_e*\ln(agr)} = -0.663$) as still positive but with a lesser effect ($\beta_{\ln(agr)} + \beta_{icms\_e*\ln(agr)} = 0.193$) (see Model 4 in Table 3). A similar pattern applies to the correlation of population density: the effect with an ICMS-E in place appears be weaker but in the same direction ($\beta_{\ln(pop)} + \beta_{icms\_e*\ln(pop)} = 1.846–1.006 = 0.840$). Additionally, we find a positive significant correlation of federal level PA share with municipal level PA share and a significant negative interaction of federal level PA coverage with ICMS-E schemes. This means that, on average, the ICMS-E creates a crowding out effect of federal (and state) PA on municipal PA – which constitutes some sort of government level competition. This crowding out pattern may relate to the relative scarcity of available area and only becomes apparent once there is no longer abundant area available for conservation.

Overarching Issues

There are positive and significant correlations of ICMS-E schemes with both total and municipal PA coverage. However, this may relate to a reverse causal effect such that the introduction of ICMS-E is following the designation of a large share of PA instead of the ICMS-E providing an incentive to designate additional PA.

Therefore, we included a time variable to account for trends in the PA data and an interaction of the ICMS-E dummy with the time variable. For total PA coverage the time variable is positively and significantly correlated and its interaction term with ICMS-E is negatively and significantly correlated (Table 2). This means that the average yearly increase in overall PA share is lower once an ICMS-E scheme is in place. Although this may also be due to increasing opportunity costs of additional PA designation, the reverse causal relation cannot be ruled out for the overall PA share. ICMS-E could be a consequence of an above average designation of federal and state level PA. In such a case, the additional budget may rather compensate for corresponding land-use restrictions and nevertheless change the mind-set of local governments, which commonly perceive PA as an obstacle to economic development.

In fact, for municipal PA coverage the pattern is different. Both the time variable and its interaction term have positive and significant coefficients once other interactions are included. This means that the average yearly increase in municipal PA share increases once there is an ICMS-E scheme. This indicates an incentive effect for municipalities to designate additional PA when there is an EFT scheme in place. Altogether, this means that the hypothesis we derived from the simplistic microeconomic model presented earlier cannot be falsified. Although

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the ICMS-E schemes may be a consequence of a high *overall* share of PA, e.g. national and state level designations, on average we observe a local response to the creation of an EFT. Municipalities designate additional PA. This also means a decentralization effect regarding the location of further PA, because the additional ones are designated at municipal level. We would cautiously infer these to be a consequence of the fiscal incentive effect inherent in the ICMS-E scheme. By acknowledging the spill-over benefits of conservation and compensating for the local costs associated with conservation through a share of fiscal transfers, the public good provision of municipal PA is increased.

Last but not least, we also have to comment on the limitations of our analytical approach. Although we used the most complete data available there may be missing data points, i.e. for municipal protected areas. We found indications that there are more municipal PA, but could not gather information on either their area or their year of enactment or corresponding legal acts and therefore refrained from including these. We consider this a potential source for biased estimates (see, e.g., the large increase in the ICMS-E dummy variable and its standard deviation in Model 4, Table 2). Although we have computed standard errors robust to spatial or cross-sectional and serial dependence (Driscoll and Kraay, 1998; Millo, 2016), which are quite conservative, this might still be a potential source of biased estimates (cf. King and Roberts, 2015). A task for future research is to employ spatial estimations for panel data (cf. Millo, 2014) regarding the ICMS-E schemes in Brazil. We also did not include a continuous variable of ICMS-E schemes that accounts for the different institutional designs (see Table 1) and could give evidence of the strength of different ICMS percentages, since it is not in all cases clear what percentage is finally dedicated for the existence of PA. One particular aspect is worth mentioning, since the quantitative analysis conducted does not take into account the quality of the management of PA. So far, only in Paraná are quality criteria already included in the ICMS-E law (Loureiro *et al.*, 2008). The fact that the ICMS-E apparently leads to an increase in PA does not necessarily mean that the current land-use practice is altered much – although we suspect that the designation of a PA helps nature conservation, the topic of management quality has not been touched upon by our analysis.

Conclusion

We analyzed the effect of introducing ecological fiscal transfers in Brazilian states for panel data covering the years 1991–2009, following the pioneering introduction of ICMS-E in Paraná. Our research question was whether the ICMS-E creates an incentive to designate further PA. We presented a simplifying microeconomic model and tested the derived hypothesis econometrically controlling for unobserved individual effects, time, socio-economic variables, and other conservation policies.

We find that the introduction of ICMS-E schemes on average corresponds, *ceteris paribus*, to higher total PA coverage. This could be a consequence of an ICMS-E introduction following a high PA share, that is to say a compensation for hosting other government level PA. On the municipal level, however, there are clear indications for local responses to the implementation of EFT: after an ICMS-E introduction additional municipal PA are designated. This signals a decentralizing effect for nature conservation. Both observations are very likely a consequence of the incentive effect inherent in ICMS-E schemes.

We thereby have contributed to the literature with a first comprehensive econometric approach covering all Brazilian states and provide insights by providing a first estimation of the effects of introducing ICMS-E schemes on PA designation. The results of this study may thus advance the implementation of EFT schemes in other Brazilian states or other nations and are particularly relevant for countries in which an introduction might be expected (e.g. Germany, Poland) (cf. Schröter-Schlaack *et al.*, 2014). Especially since EFT schemes do not require any additional budget but constitute a (rather marginal) change in the allocation of tax revenue, they are relatively easy to implement. EFT schemes are thus of eminent relevance for conservation policies regarding a common shortage in public budgets at local levels and a shortfall of conservation budgets. Through incentivizing municipal PA designations EFT could help the implementation of (inter)national biodiversity targets such as the Aichi targets, the goals of the EU Biodiversity strategy, and national biodiversity strategies and action plans.

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Appendix. Descriptive Statistics

Variable	Mean	St. dev.	Min.	Max.	*N*
Total protected area share of state territory in per cent (PAtot)	11.2	15.2	0.05	98.9	513
Federal protected area share of state territory in per cent (PAfed)	6.9	12.9	0.03	92.9	513
State protected area share of state territory in per cent (PAsta)	4.0	4.9	0.0	22.8	513
Municipal protected area share of state territory in per cent (PAmun)	0.2	1.1	0.0	7.5	513
ICMS-E dummy (icms_e)	0.2	0.4	0	1	513
Share of valued added by agriculture in per cent (agr)	10.7	7.2	0.2	41.5	513
Share of valued added by industry in per cent (ser)	27.7	11.5	3.6	66.1	513
Share of valued added by service in per cent (ind)	61.5	12.5	31.7	96.0	513
Population density cap/km^2 (pop)	26.3	31.5	0.9	174.2	513
GDP per capita, R$ in thousands (inc)	6.6	4.4	2.1	27.5	513

Source: authors' calculation based on The Nature Conservancy (2014) and IPEA (2014). Monetary values in constant prices (2000R$).

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