The Effects of Local Environmental Institutions on Perceptions of Smoke and Fire Problems in Brazil

Sheila Wertz-Kanounnikoff
Kenneth M. Chomitz

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Abstract

Environmental concern in developing countries has risen rapidly over the past decade. At the same time, decentralization and civic participation in environmental policy-making have also burgeoned. This paper uses data from the Brazilian Municipal Environmental Survey 2001 to examine the causal effect of municipio (county) level environmental institutions on perceptions about environmental problems in Brazil. Consistent with models of public choice, the analysis assumes that the existence of an environmental secretary or an environmental council is related to characteristics of the municipio population. To control for endogeneity – the possibility that the presence of environmental institutions merely signals constituents’ tastes rather than influences municipal actions – the authors construct

a system of equations that identifies the causal impact of the institutions. Estimation via a trivariate probit model allows for correlation of unobserved determinants of problem perception, presence of an environmental secretary, and presence of an environmental council. The results suggest that the presence of environmental secretaries has a strong, highly significant, positive causal effect on environmental problem perception. Presence of local environmental councils with civic participation has a significant but weaker impact on environmental problem perception. The authors conclude that local environmental institutions indeed shape local environmental awareness and that participatory institutions can influence local government.

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Sheila Wertz-Kanounnikoff

Institute for Sustainable Development and International Relations (Iddri), Paris

Kenneth M. Chomitz¹

World Bank, Washington D.C.

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¹ Corresponding author: kchomitz@worldbank.org

Introduction

Environmental concern and associated social movements in developing countries have risen rapidly over the past decade, and public opinion polls show that levels of environmental concern in developing countries often exceed those of developed countries (Steinberg 2005). One way to translate public environmental concern into improved environmental outcomes is to formally incorporate participatory environmental mechanisms into local governments. As in other spheres of public life, civil society participation is hypothesized to contribute to government's greater awareness of environmental issues and to the formulation of more effective and implementable responses (Meadowcroft 2004, Ribot 2002). A well-known Brazilian example of successful civil society involvement in public policy is the experience with local participatory budgeting which started in Porto Alegre and expanded to 170 other cities by 2004 (Avritzer 2006, Wampler and Avritzer 2005, Santos 1998).

This hypothesis raises two linked questions. First, what are the determinants of demand for local environmental institutions? Are they strongly linked to income and education, as the theory behind the Environmental Kuznets Curve would suggest? Second, once in place, do these institutions shape local government responses? In practice, these questions are difficult to disentangle, because unobserved factors are likely to influence both the existence of institutions and the nature of municipal perceptions and actions. In this paper, we address both questions through an econometric strategy that attempts to isolate the causal impact of institutions.

Brazil provides a good test-bed for this study, because it has formally-chartered participatory environmental institutions, and because it presents continental-level variation between localities in average income, education, size, rurality, and environmental condition while holding constant national laws and institutions. Since the adoption of a new constitution in 1988, Brazilian environmental policy-making has undergone fundamental changes towards

greater decentralization and enhanced civil society participation. Its more than 5000 *municípios* (municipalities, both rural and urban) have locally-elected mayors and municipal councils. Municipal government allows for the establishment of environmental secretaries and for the existence of advisory councils for particular sectors, including the environment, in which civil society has the opportunity to participate (MMA 2006). By 2001, 31.5 % of the over 5000 *municípios* had a local environmental secretary; 34 % possessed a local environmental council and 14% reported local environmental councils with active civil society participation (IBGE 2002).

In this paper, we assess the impact of these two institutions – the environmental secretary and the environmental council – on the perception of two environmental problems: forest and land fires; and the smoke associated with them. Fires are used in Brazil for pasture maintenance and to clear forest for pasture or cropland. Fires are environmental problems because they are sometimes associated with illegal deforestation and because escaped fires can damage farms and forests. Smoke from these fires is an additional problem, which can cause widespread health damage and disruption to air transport and other activities. Here we determine whether *municípios* with environmental institutions are more likely to report having these problems, controlling for objective measures of the problems' severity.

In the next section we describe our methods and data. In the section thereafter, we present our model together with estimation results. The last section discusses implications of these results.

Methodology

Level of analysis: minimum comparable areas (MCA) 2000-2001

Conceptually, the analysis was performed at the level of the *município*. However, some *municípios* fissioned or recombined between 2000 and 2001, and our data include elements from before and after this redefinition. To integrate the data, we use the *minimum comparable areas (MCA)* — where an MCA consists of the smallest set of *municípios* that has a consistent boundary over time. Of 5480 MCAs, 45 consist of aggregates of multiple *municípios* comprising in total 125 *municípios* of year 2001. To assemble municipal-level categorical data to MCAs we use the majority value; to integrate continuous data we use sums for absolute and means for relative information.

Data

Environmental institutions: The data is at the *município* level and taken from the Brazilian Municipal Environmental Survey conducted in 2001 (IBGE 2002). We look at two environmental institutions. The first is the presence of a dedicated environmental secretary within the municipal administration. The municipal environmental secretary (*Secretaria Municipal de Meio Ambiente*, SMMA) is the local branch of Brazil's national system of the environment (*Sistema Nacional do Meio Ambiente*, SISNAMA) in charge of implementing municipal environmental policy. The second is the presence of an *active environmental council*. In Brazil, a municipal environmental council (*Conselho Municipal de Meio Ambiente*, CMMA) has the function of advising and assessing the municipal executive power, on environment-related subjects (MMA 2006). In this paper, we use an active environmental council as one that is reported to meet more than once a year and at least half of whose members are from civil society.

Municipal environmental councils are found in 34% of the *municípios* and 26% provided information on meeting frequency (IBGE 2002). 8.86% these municipal environmental

councils are situated in the Legal Amazon. About 34% of Brazil's *municípios* reported on civil society participation in environmental council meetings; all others do either not own an environmental council or reported that the survey question (or available answers in the survey) on civil society participation in council meetings did not apply. In Table 1 environmental council meeting frequency and civil society participation are cross-tabulated for the 1432 *municípios* (MCA's, see above) for which information was available. To ensure a significant number of observations, we define all those municipal environmental councils that reported regular council meeting frequency (more than once a year) and high civic participation (at least 50%) as *active environmental councils*. In total, 787 out of 1862 local environmental councils correspond to this definition, of which 69 are situated in the Legal Amazon. Map 2 visualizes the distribution of local environmental secretaries and active environmental councils in Brazil.

Council meeting frequency	Civil Society Participation				Total
	none	< 50%	50%	> 50%	
irregular meetings	6	90	155	111	362
meetings once per year	4	30	44	32	110
bi/trisemestral meetings	4	54	118	115	291
semestral meetings	2	22	67	42	133
mensual meetings	4	87	250	195	536
Total	41	389	815	624	1432

Table 1: Local environmental councils – meeting frequency versus civil society participation (IBGE 2002)

Environmental problem perception: These municipal level data was also obtained from the Brazilian Municipal Environmental Survey (IBGE 2002). The survey presented the municipal respondent with a list of environmental problems and asked which were locally salient. We

tallied reports of smoke (from forest and land fires, excluding urban pollution) and fire (from forest fires). Map 3 depicts the spatial distribution of smoke and fire problem perception.

Education: The data for 2000, at municipio level, obtained from the Brazilian Research Institute of Applied Economics (IPEA) and derived from the Census, presents *average years of adult education (above 25 years)* as depicted in Map 4.

Income: This data for 2000, at municipio level, from the Brazilian Research Institute of Applied Economics (IPEA) but ultimately derived from the Demographic Census, refers to *mean per capita income* in Brazilian Reais for 2000 and is visualized in Map 5.

Population: At municipio level, this data for 2000, and classified into rural and urban population share, originated from the Brazilian Institute of Geography and Statistics (IBGE). We use the municipio's rural population share to compute *rural proportion* of municipal population (Map 6).

Fire Spots (heat sources): This data for 2000 and 2001 originates from the Brazilian Institute for Space Research (INPE). The heat sources were measured by the NOAA-12 satellite during the passage at 6-7 p.m. Brasilia local time; the spatial resolution is 1.1 km. For our analysis, we calculate *fire spot density 2000-01* based on a spatial moving average in order to account for fires in neighboring municipio. We calculate for each 1 km grid cell the mean number of fire spots within a 25x25 cell neighborhood to then calculate the mean of this derived variable over the cells within the MCA. (Map 7).

Biome: This data originates from the Brazilian Institute for the Environment and Natural Resources (IBAMA) and World Wildlife Fund (WWF) based on Dinerstein et al. (1995). We grouped the originally 10 biome classes into 5 biome categories, notably *Amazonia* (including the biome classes *Costeiro* and *Ecotono Cerrado-Amazonia*), *Caatinga*, *Mata Atlantica*,

Cerrado (including the biome classes *Pantanal*, *Ecotono Cerrado-Caatinga* and *Ecotono Caatinga-Amazonia*) and *Campos Sulinos* (Map 8).

The Model

The model consists of three equations. We explain the presence of an environmental secretary, of an environmental council, and of perceived problems with fire or smoke.

Presence of environmental institutions

The presence of environmental institutions in a *município* reflects both demand and supply considerations. The demand for institutions is typically captured by the standard median voter model from public choice theory (Black 1948, 1952; Holcombe 1989; Congleton 2002). In this model, social choice reflects the preferences of a voter with median values of personal characteristics affecting choice, under a simple majority voting rule. This motivates econometric models relating social choice to median voter characteristics. In the case of super majority voting rule, however, improved accuracy of predictions tends to be obtained with the use of mean rather than median voter characteristics (Caplin and Nalebuff 1991, Ma and Weiss 1995, Thomsen and Torenvlied 2005).

We assume that the presence of an environmental secretary or active environmental council reflects the preferences of municipal citizens. We relate this observed institutional demand to mean characteristics of the voters, medians being unavailable. In fact, the mean voter model might capture the stronger influence of high-income or high-education elites within the *município*.

Specifically, we hypothesize that the preference for environmental institutions at municipal level is strongly positively related to income and education, and to be affected also by place of residence (rural/urban) and biome of residence (fragile/robust). Note however that the

presence of environmental institutions can also be related to political or other (to the municipality) exogenous factors including fiscal transfers or donor funding – possibilities which we have not addressed within the context of this study and which could be insightful improvements for a follow-up study.

Table 3 provides a tabulation of *municipios* categorized by mean income and education categories (proxies for the corresponding medians). It shows that presence of environmental institutions is indeed associated with higher income and education levels.

On the supply side, we assume that *municipios* exhibit strong scale economies in their ability to support administrative departments and participatory councils. Brazilian *municipios* vary in population from a few thousand to several million, so one would assume that other things equal, the smaller *municipios* would be less likely to have environmental secretaries and councils.

Problem perception

We hypothesize that the likelihood of increased environmental problem perception is associated with:

- (i) *Presence of environmental institutions*: Environmental institutions such as public environmental agencies or organizations are expected to promote environmental education and environmental engagement, thus raise the sensitivity regarding environmental problems. In our analysis, environmental institutions are represented by (i) presence of a local environmental secretaries and (ii) presence of a local environmental council with civic participation. Table 2 depicts a tabulation of problem perception, environmental institution and population. About 17% of *municipios*, comprising 28% of Brazil's population, report fire as a problem. The proportion of

these municipios with environmental secretaries or active environmental councils is about 50% higher than in municipios without reported fire problems.

- (ii) *Education:* Environmental education is supposed to increase awareness of the biophysical environment and associated problems (Stapp et al. 1969). We hypothesize that higher levels of general education are associated both with environmental education and with demand for environmental amenities.
- (iii) *Income:* Consonant with the Environmental Kuznets Curve hypothesis (Grossmann and Krueger 1991), we expect that higher per-capita income will lead to a greater perception of environmental problem. In our sample, education and income are highly correlated ($r=0.884$), so that it may be difficult to disentangle the effects of these variables.
- (iv) *Rurality:* We also assume that rurality will matter in environmental problem perception although the effects are ambiguous. Urban populations might be expected to have a higher demand for biodiversity conservation, since they do not bear its direct costs. On the other hand, rural inhabitants are naturally embedded in and eventually more dependent on the state of natural environment and may be particularly sensitive to damages from smoke and fire (Berenguer et al. 2005).
- (v) *Biome type:* The biome type in which a municipio is located is expected to matter as problem perception will presumably increase if local vegetation types are more susceptible to flames, if local property is more exposed to fire threats, or if fire is routinely used as a land management tool.
- (vi) *Fire spot density:* We assume that the subjective perception of fire and smoke problems is related to objective measures of fire incidence. To account for fire in neighboring *municipios*, we used a spatial moving average approach to calculate fire spot density.

- (vii) *Municipio area:* While fire spot density controls for the intensity of fire or smoke, the addition of area to the model allows the absolute quantity of fire or smoke to affect municipal perceptions.

Trivariate probit model

The modeling challenge lies in the endogeneity of environmental institutions. A correlation between the presence of environmental institutions and of problem perceptions might be attributed to some common but unobserved factors. That is, the presence of environmental institutions may simply be an indicator of the locality's interest in environment, and not a causal influence on problem perception.

To control for this possibility, we use *municipio* population as an instrument for the presence of environmental institutions. Based on the supply-side, economies-of-scale argument, we propose that this variable affects the presence of institutions but, after controlling for education, income, rurality, and biome, has no influence on problem perception. Further, we allow for correlation among unobserved determinants of institutional presence and of problem perception. This allows for the possibility that more environmentally sensitive places are more likely both to perceive problems and to establish environmental institutions.

This is done via a trivariate probit model. The specification of the three-equation model is:

$$\text{secretary}^* = \beta_1 X + \gamma_1 \ln \text{population} + \varepsilon_1 \text{ with } \text{secretary} = 1 \text{ if } \text{secretary}^* > 0 \mid \text{secretary} = 0 \text{ otherwise}$$

$$\text{council}^* = \beta_2 X + \gamma_2 \ln \text{population} + \varepsilon_2 \text{ with } \text{council}_i = 1 \text{ if } \text{council}^* > 0 \mid \text{council} = 0 \text{ otherwise}$$

$$\text{problem}^* = \beta_3 X + \delta_1 \text{secretary}^* + \delta_1 \text{council}^* + \lambda_1 \text{fire spot density} + \lambda_2 \text{area} + \varepsilon_3$$
 with

$$\text{problem} = 1 \text{ if } \text{problem}^* > 0 \mid \text{problem} = 0 \text{ otherwise}$$

$$\text{cov}(\varepsilon_1, \varepsilon_2) = \rho_1$$

$$\text{cov}(\varepsilon_1, \varepsilon_3) = \rho_2$$

$$\text{cov}(\varepsilon_2, \varepsilon_3) = \rho_3$$

The first and second equations evaluate respectively the functional relationship between presence of environmental secretary (secretary) and presence of an active environmental council (council), against a number of explanatory variables. The set of explanatory variables consists of municipio population (the instrument), education and per capita income (reflecting the underlying demand for environmental quality), rural population share and biome classes.

The third equation then relates environmental problem perception (problem) to a common set of explanatory variables, excluding population size and including the presence of the secretary and the council. It lastly also contains fire spot density as an objective measure related to fire and smoke problem perception.

The probit model is estimated with a procedure developed by Terracol (2002) which uses the Geweke-Hajivassiliou-Keane (GHK) smooth recursive simulator.

All municipios (MCAs) are used for the analysis. This allows for accurate estimation and identification of the institutional presence equations, and tests whether absence of fires is related to non-perception of fires.

Estimation results

We now turn to the regression results. Table 4 provides the summary statistics and Table 5 reports the output for the trivariate probit regressions for smoke and fire problem perception.

The correlation coefficient between the error terms of secretary and council is positive and significant, indicating common unobserved factors favoring both forms of environmental institution. Contrary to expectation, the correlation between the errors for the problem perception and the presence of each environmental institution are however negative and significant.

With regard to the presence of environmental institutions (equations 1 and 2), the coefficients are relatively stable across the two problem types, as one would expect. More populous *MCAs* are much more likely to have both secretary and council, supporting the hypothesized scale economies effect. Controlling for this, *MCAs* with higher rural proportions were strongly and significantly more likely to have both institutional features. This was contrary to expectations that environmental interests are primarily urban. Amazonian *MCAs* were more likely (other things equal) to have an environmental secretary than other biomes but generally less likely to have an active environmental council. Income had a positive effect that was statistically significant but of negligible magnitude. Education was positively related to presence of environmental institutions.

The third equation assesses the determinants of problem perception. An objective measure of fire incidence is very strongly and significantly correlated with perception of smoke as a problem; the relationship between fire spot density and fire problem perception is positive but weaker and not statistically significant. This may reflect a tendency for field fires to be controlled, so that they are obnoxious only because of the smoke they produce. Holding fire incidence and other variables constant, the presence of a local environmental secretary is strongly, significantly (significance at 1%) and positively associated with perceptions of smoke and fire problems. Presence of an active environmental council is also significantly associated with environmental problem perception, though the effect is approximately half as large as that of the secretary. Taken together, the presence of both institutions boosts the

probit index of problem perception by a full unit or more. Holding constant the institutional variables, rurality and education are negatively associated with problem perception. The rurality effect is quite strong, suggesting that rural populations – who use fire for field maintenance or forest clearance – are less likely to perceive it as a problem.

Summary and conclusions

This paper analyzes the functional relationship between presence of local environmental institutions (environmental secretaries and environmental councils with active civic participation) and local environmental problem perception in Brazil. We account for the possible endogeneity between environmental institutions and environmental problem perception as well as for further correlations of unobserved variables by using a simultaneously estimated three-equation probit model, and by incorporating objective measures of problem incidence. We find a significant and positive effect of population size, education, and rurality on the presence of local environmental institutions. Amazonian *municípios* are more likely to have an environmental secretary but less likely to have an active environmental council. We find strong evidence that the presence of environmental institutions has a significant and positive effect on problem perception. The strongest effect is from the presence of an environmental secretary. However, the presence of active environmental councils augments the likelihood of problem perception.

The significance of these findings extends beyond the environmental domain, contributing to evidence that participatory institutions can influence local government. Potential follow-on research could look at the behavioral impact of these institutions on observable actions of government, and could complement the econometric analysis with in-depth qualitative analyses of the functioning of these institutions.

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Data Sources

Data on heat sources: INPE-Proarco (www.dpi.inpe.br/proarco/bdqueimadas/)

Município level statistical data and spatial boundaries: IBGE (www.sidra.ibge.gov.br/)

Economic and social data: IPEA (www.ipeadata.gov.br)

Tables

	Municipios (MCA's)	Total population	Rural population	Mean rural proportion	Environmental secretary		Active environmental council	
				rural population / total population	presence		presence	
	[number]	[number]	[number]	[%]	[#]	[%]	[#]	[%]
Total Brazil	5,477	170,000,000	31,800,000	18.7%	1,725	31.5%	787	14.4%
Brazil: Smoke problem perception								
yes	768	39,100,000	5,803,418	14.8%	332	43.2%	152	19.8%
no	4,709	131,000,000	26,000,000	19.8%	1,393	29.6%	635	13.5%
Brazil: Fire problem perception								
yes	941	47,900,000	7,206,446	15.0%	401	42.6%	190	20.2%
no	4,536	122,000,000	24,600,000	20.2%	1,324	29.2%	597	13.2%

Table 2: Tabulation of environmental institutions and environmental problem perception in Brazil

	Municipios	Population	Rural proportion	Environmental secretary		Active environmental council	
			rural population / total population	presence		presence	
	[number]	[number]	[%]	[#]	row [%]	[#]	row [%]
Total Brazil	5,477	170,000,000	41.1%	1,725	31.5%	787	14.4%
adult education < 3 years	1,363	19,217,039	59.1%	305	22.4%	80	5.9%
income < 100 R\$	1,250	17,300,000	59.5%	269	21.5%	73	5.8%
income 100-200 R\$	112	1,909,302	55.2%	36	32.1%	7	6.3%
income > 200 R\$	1	7,737	76.3%	0	0.0%		0.0%
adult education 3-4 years	1,284	17,494,311	47.5%	390	75.7%	125	9.7%
income < 100 R\$	441	6,437,699	46.6%	125	75.8%	40	9.1%
income 100-200 R\$	782	10,300,000	47.7%	243	75.2%	80	10.2%
income > 200 R\$	61	756,612	52.0%	22	81.5%	5	8.2%
adult education 4-5 years	1,580	21,083,061	38.1%	477	68.5%	219	13.9%
income < 100 R\$	35	562,395	39.7%	11	91.7%	1	2.9%
income 100-200 R\$	814	12,800,000	38.2%	256	70.3%	108	13.3%
income > 200 R\$	731	7,720,666	37.9%	210	65.6%	110	15.0%
adult education >5 years	1,250	111,493,452	18.7%	553	60.4%	363	29.0%
income < 100 R\$							
income 100-200 R\$	110	6,493,452	22.7%	62	71.3%	25	22.7%
income > 200 R\$	1,140	105,000,000	18.3%	491	59.2%	338	29.6%

Table 3: Income and education by presence of environmental secretary and presence of active environmental councils in Brazil's *municípios*/ MCA (IBGE 2002)

Variable	Observation	Mean	Std. Dev.	Min	Max
Income per capita 2000 [R\$]	5476	170.38	96.09	28	955
Mean adult education [years]	5476	4.03	1.29	1	10
Rural population 2000 [number]	5476	5813.06	10479.65	0	621065
Total population 2000 [number]	5476	30989.98	187248.90	795	10400000
Log population	5476	9.36	1.11	7	16
Proportion of rural population	5476	0.41	0.23	0	1
Biome category	5476		0.93	1	5
Active environmental council [yes/no]	5476		0.35	0	1
Environmental secretary [yes/no]	5476		0.46	0	1
Density of fire spots 2000-01 [spots/625 km2]	5476	0.02	0.04	0	0
Log municipio area	5476	6.21	1.28	1	12
Fire problem perception [yes/no]	5476		0.38	0	1
Smoke problem perception [yes/no]	5476		0.35	0	1

Table 4: Summary statistics

Model	Triprobit 1			Triprobit 2		
	Environmental Secretary	Environmental council	Fire problem perception	Environmental Secretary	Environmental council	Smoke problem perception
Equation						
Log population size 2000	0.33 (0.02)***	0.27 (0.02)***		0.32 (0.02)***	0.27 (0.02)***	
Mean adult education 2000 [years]	0.15 (0.03)***	0.11 (0.04)***	-0.10 (0.04)**	0.15 (0.03)***	0.11 (0.04)***	-0.10 (0.04)**
Mean per capita income [R\$]	0.00 (0.00)*	0.00 (0.00)***	0.00 (0.00)	0.00 (0.00)*	0.00 (0.00)***	0.00 (0.00)
Rural population share [%]	0.47 (0.11)***	0.41 (0.14)***	-0.48 (0.12)***	0.46 (0.11)***	0.41 (0.14)***	-0.74 (0.13)***
Biome category [omitted "Amazon"]						
<i>Caatinga</i>	-0.68 (0.07)***	-0.17 (0.10)*	-0.13 (0.09)	-0.70 (0.07)***	-0.19 (0.10)*	-0.20 (0.09)**
<i>Mata Atlantica</i>	-0.32 (0.07)***	0.20 (0.09)**	-0.05 (0.09)	-0.33 (0.07)***	0.19 (0.09)**	-0.15 (0.09)*
<i>Cerrado</i>	-0.27 (0.07)***	0.27 (0.09)***	-0.04 (0.08)	-0.28 (0.07)***	0.27 (0.09)***	-0.21 (0.08)**
<i>Campos Sulinos</i>	-0.40 (0.13)***	0.56 (0.14)***	-0.54 (0.18)***	-0.41 (0.13)***	0.56 (0.14)***	-0.44 (0.18)**
Environmental secretary			0.76 (0.11)***			0.66 (0.12)***
Active environmental council			0.35 (0.12)***			0.34 (0.14)**
Fire spot density [spots / 625 km ²]			0.73 (0.53)			3.94 (0.52)***
Log area			0.11 (0.02)***			0.11 (0.02)***
Constant	-3.93 (0.23)***	-4.67 (0.29)***	-1.19 (0.22)***	-3.87 (0.23)***	-4.68 (0.29)***	-1.43 (0.23)***
$\rho_{secretary \times council}$	0.22 (0.03)***			0.22 (0.03)***		
$\rho_{secretary \times perception}$	-0.33 (0.06)***			-0.31 (0.06)***		
$\rho_{council \times perception}$	-0.11 (0.06)*			-0.16 (0.07)**		
Observations	5476			5476		
Log likelihood	-7,490.96			-7,163.92		
Wald χ^2 (d.f.)	1,365.23 (27)			1,385.93 (27)		
p > χ^2	0.00			0.00		
% correct prediction	31.5%	31.1%	18.5%	31.5%	31.1%	22.0%

Notes: z-scores in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 5: Output of trivariate probit regressions for all *municípios* of Brazil

Maps

Map 1: Minimum comparable areas 2001-00

Map 2: Local environmental institutions in Brazil (IBGE 2002)

Map 3: Environmental perception (IBGE 2002)

Map 4: Mean adult education 2000 (IPEA)

Map 5: Per capita income 2000 (IPEA)

Map 6: Rural proportion

Map 7: Fire spot density 2000-01 (INPE-Proarco)

Map 8: Biomes (IBAMA-WWF 1995)