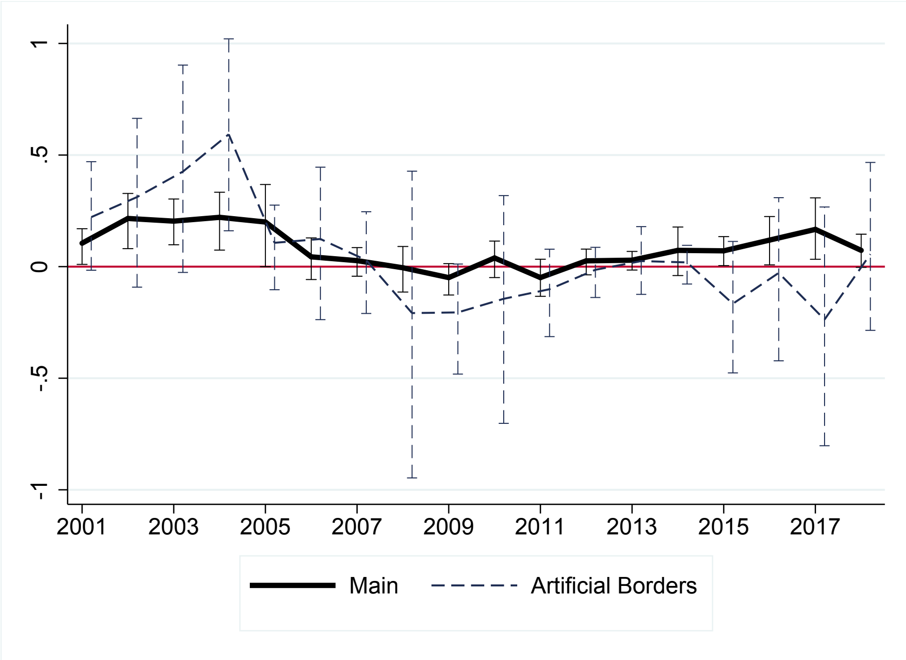
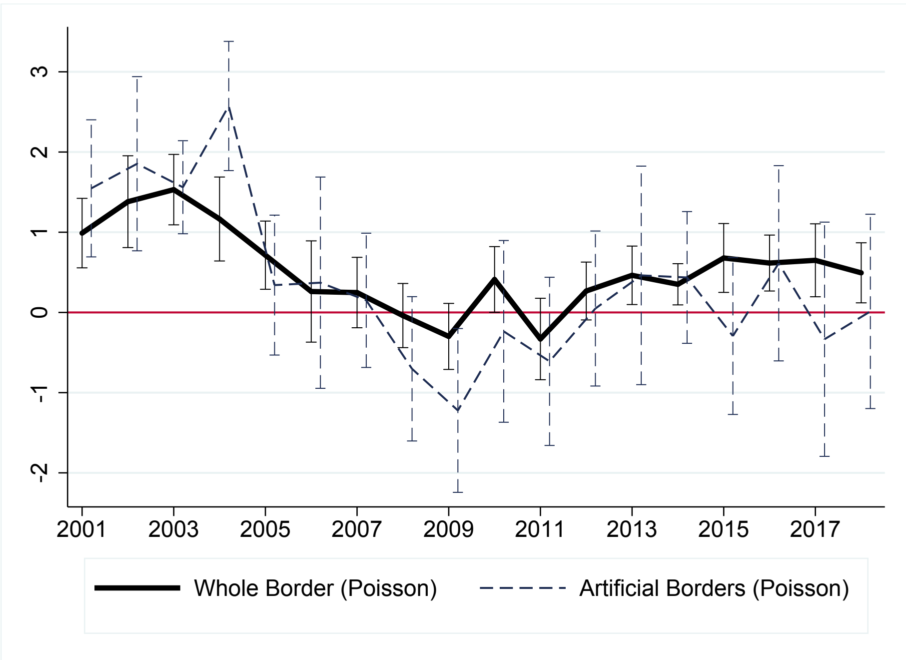
Appendix (for online publication only)

A Appendix Figures and Tables

In this section we present the tables with summary statistics of the data and the estimates presented in Figures 5 and A1, as well as all robustness exercises mentioned in the paper. We also present the main robustness tests graphically.



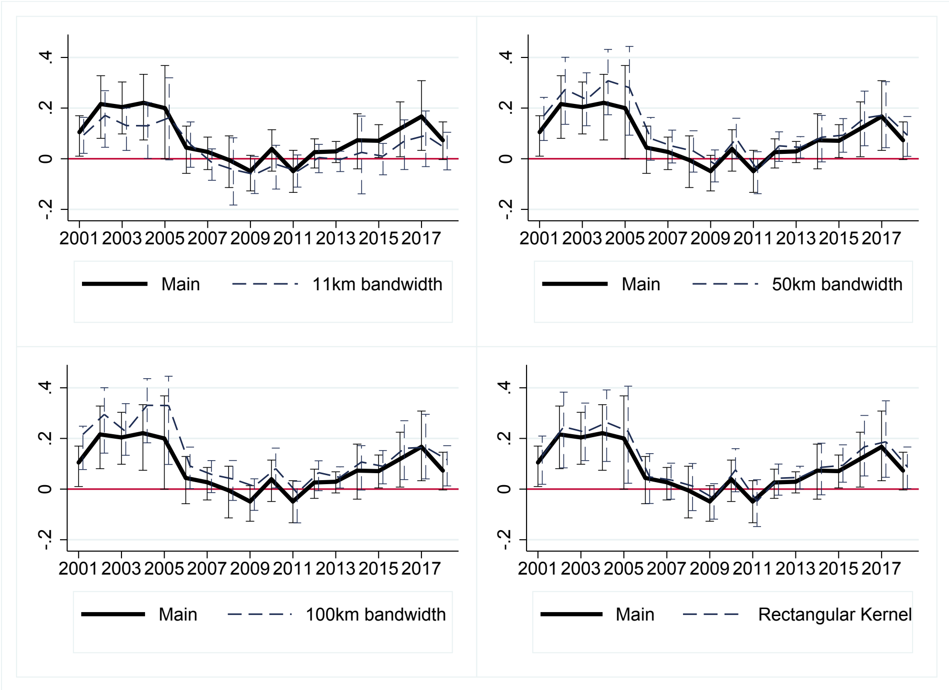
(a) OLS model



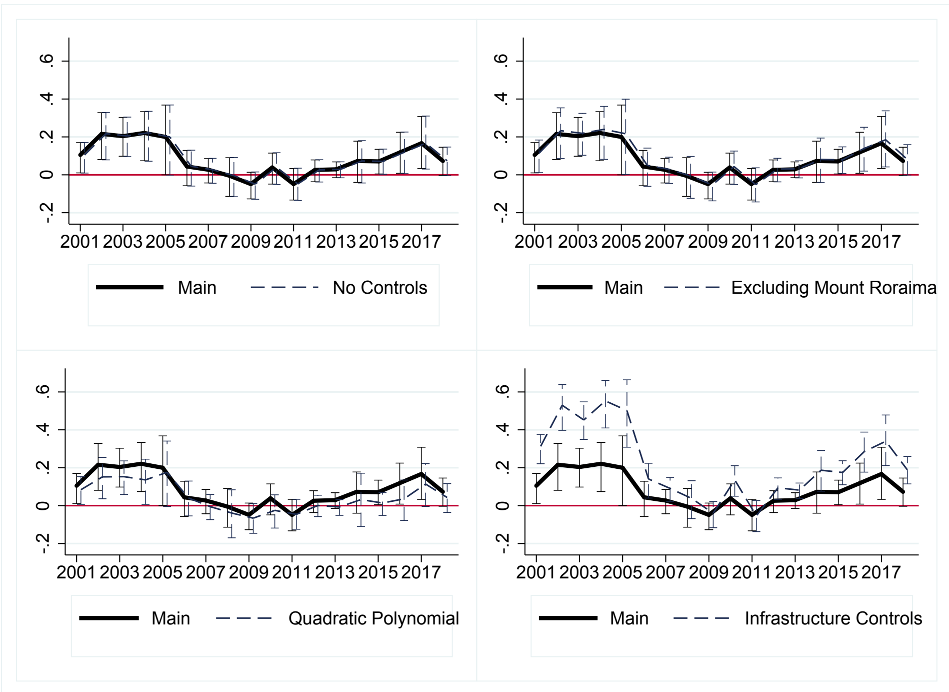
(b) Poisson model

Figure A1: Artificial Border Segments

This figure shows the results when one restricts attention to artificial borders. It plots the regression discontinuity coefficients of the Brazilian effect, γ, on the percentage of annual forest loss by year, from equation (1) estimated with linear running variables and 25km bandwidth. Solid lines shows effects estimated with the whole border, and dashed lines shows effects estimated restricting the sample to pixels around artificial borders. The top panel (a) estimates the model using OLS regressions – presented in column 1 Table $A3$ and column 1 Table $A5$ – and the bottom panel (b) estimates using a Poisson model – presented in columns 3 and 4 Table $A5$. The vertical bars represent 95 percent confidence intervals.



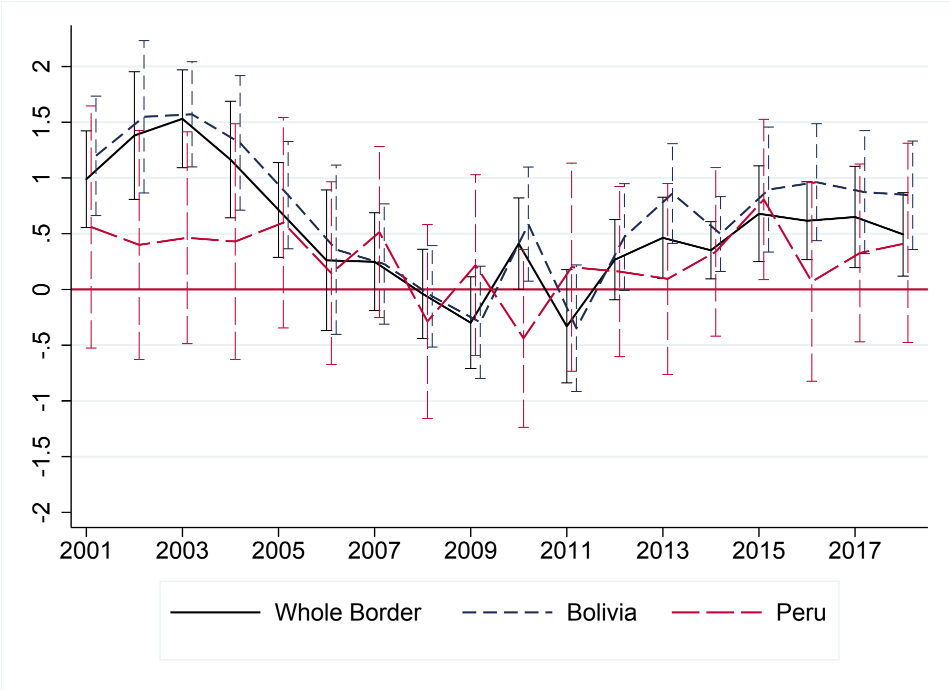
(a) Different Bandwidth



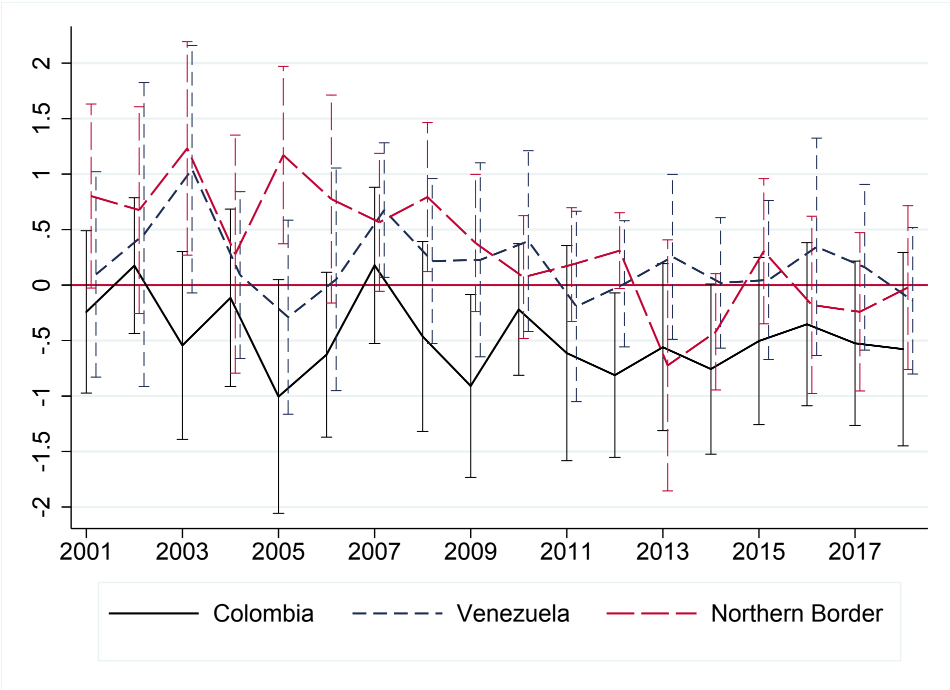
(b) Robustness

Figure A2: Regression Discontinuity Coefficients by Year

This figure shows the results for different bandwidths and robustness specifications. It plots the regression discontinuity coefficients of the Brazilian effect, γ, on the percentage of annual forest loss by year, from equation (1). The solid lines use a 25 km bandwidth – our main specification – presented in column 1 Table *A3*. The upper panel shows specifications with linear running variables and different bandwidths (dashed lines) from 11 km to 100 km as indicated in each panel – presented in Table *A3*. The bottom panel shows different specifications (dashed lines) with linear running variables and a 25 km bandwidth – presented in Table *A4*. The vertical bars represent 95 percent confidence intervals.



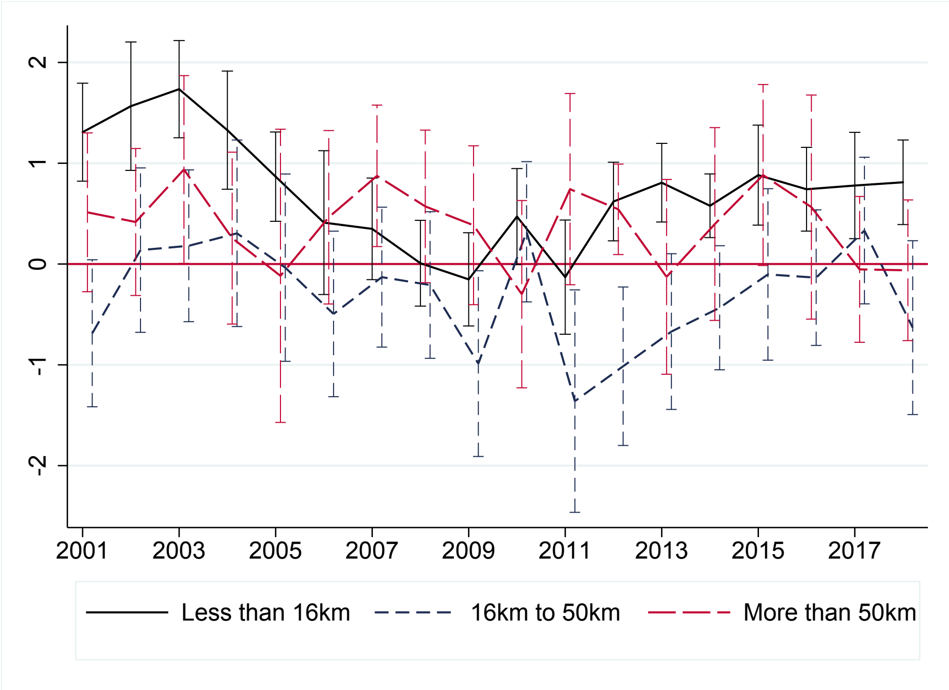
(a) Bolivia and Peru



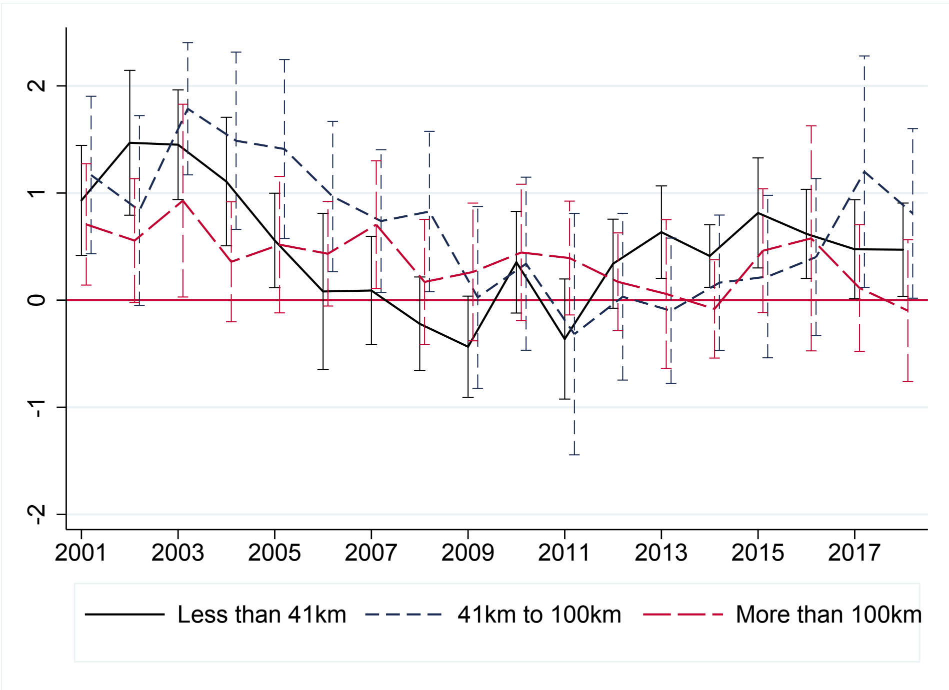
(b) Colombia, Venezuela and Guyana, Suriname and French Guiana

Figure A3: Regression Discontinuity Coefficients by Country Border

This figure shows the heterogeneous effects by country border estimated using a Poisson model. It shows the regression discontinuity coefficients of the Brazilian effect, γ, on the percentage of annual forest loss by year, from equation (1) with linear running variables and 25 km bandwidth. The upper panel shows our main specification with the whole border (the solid line) and the border segments with Bolivia and Peru, and the bottom panel (b) shows estimates for the border segments with Colombia, Venezuela and the countries in the Northern border (i.e., Guyana, Suriname and French Guiana), presented in Table *A7*. The vertical bars represent 95 percent confidence intervals.



(a) Distance to roads



(b) Distance to villages

Figure A4: Regression Discontinuity Coefficients by Distance to Roads and Villages

This figure shows the heterogeneous effects by distance to roads (panel a) and villages (panel b) estimated using a Poisson model. It shows the regression discontinuity coefficients of the Brazilian effect, γ, on the percentage of annual forest loss by year, from equation (1) with linear running variables and 25 km bandwidth. Solid lines depict the results restricting the sample to the first 1/3 percentile of distance, dashed dark line the 2/3 percentile and the red long-dashed lines the top 1/3 percentile. All estimates presented in Table A8 and A9. The vertical bars represent 95 percent confidence intervals.

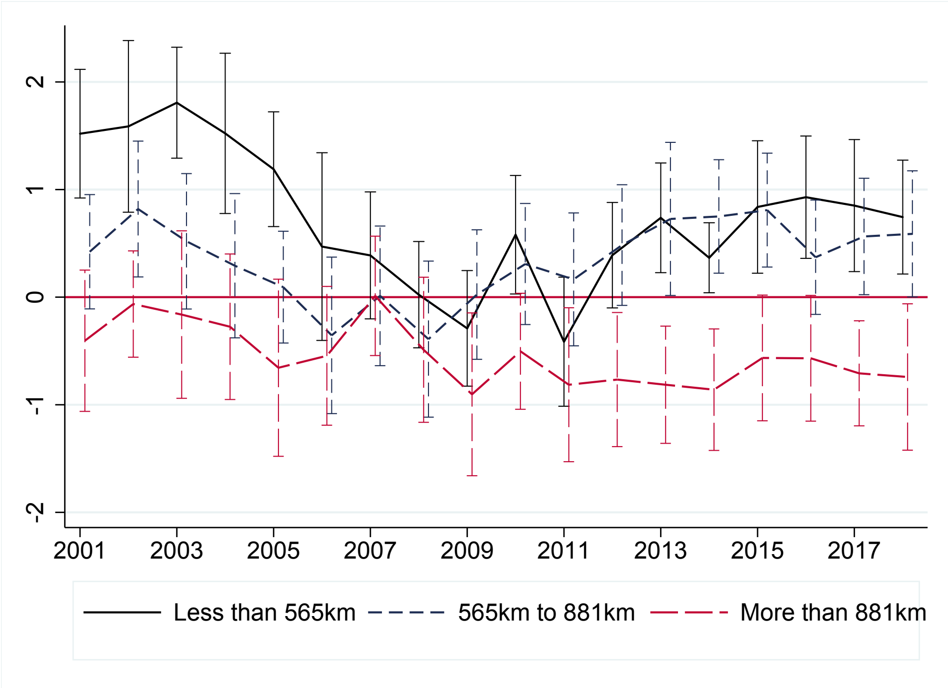


Figure A5: Regression Discontinuity Coefficients by Distance to Enforcement Base

This figure shows the heterogeneous effects by distance to enforcement base (IBAMA/MMA center) estimated using a Poisson model. It shows the regression discontinuity coefficients of the Brazilian effect, γ, on the percentage of annual forest loss by year, from equation (1) with linear running variables and 25 km bandwidth. Solid lines depict the results restricting the sample to the first 1/3 percentile of distance, dashed dark line the 2/3 percentile and the red long-dashed lines the top 1/3 percentile. All estimates presented in Table *A*10. The vertical bars represent 95 percent confidence intervals.

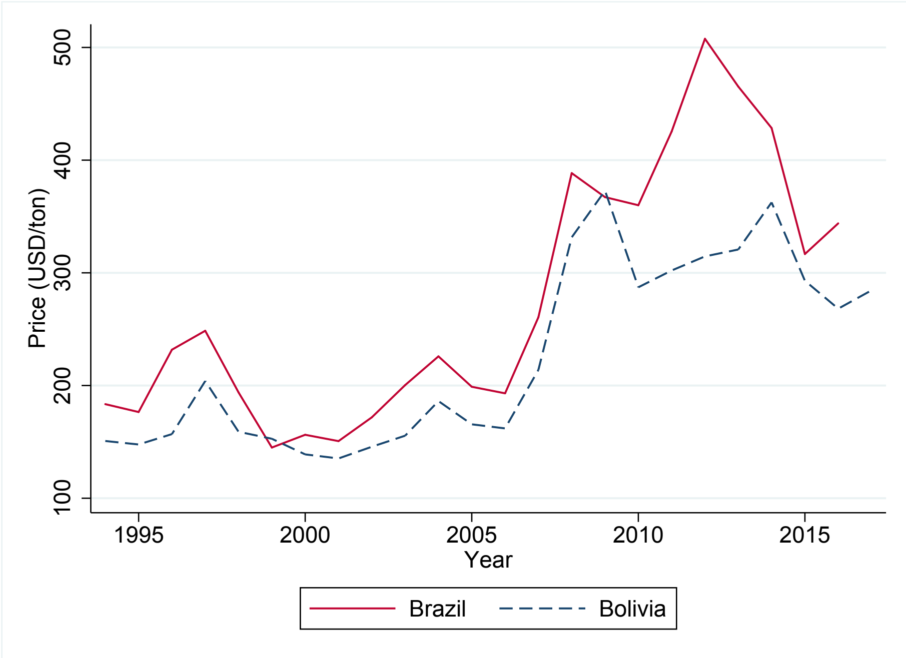
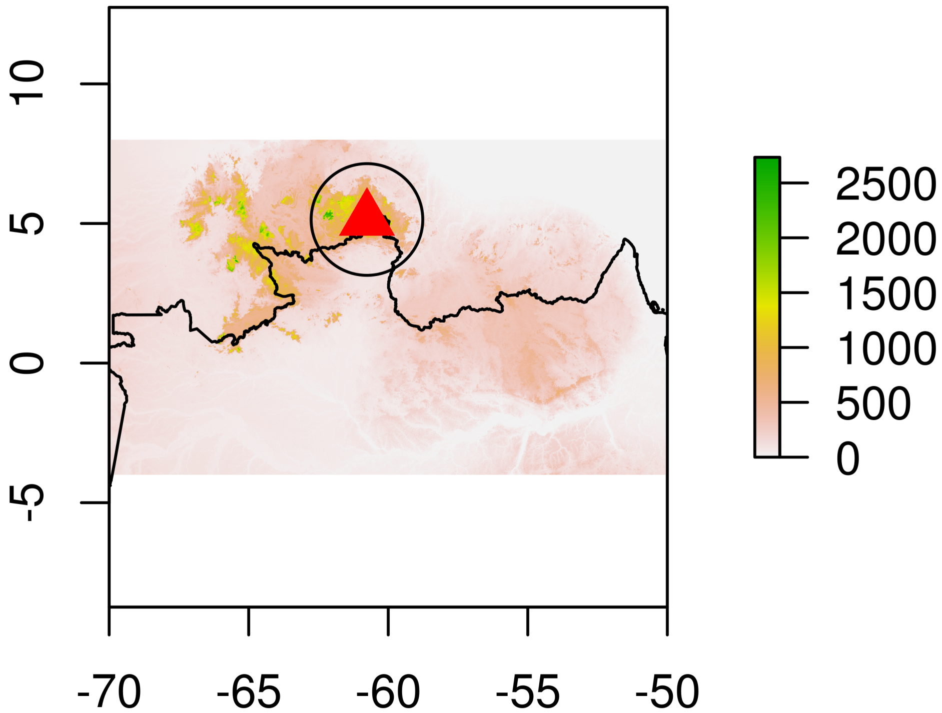
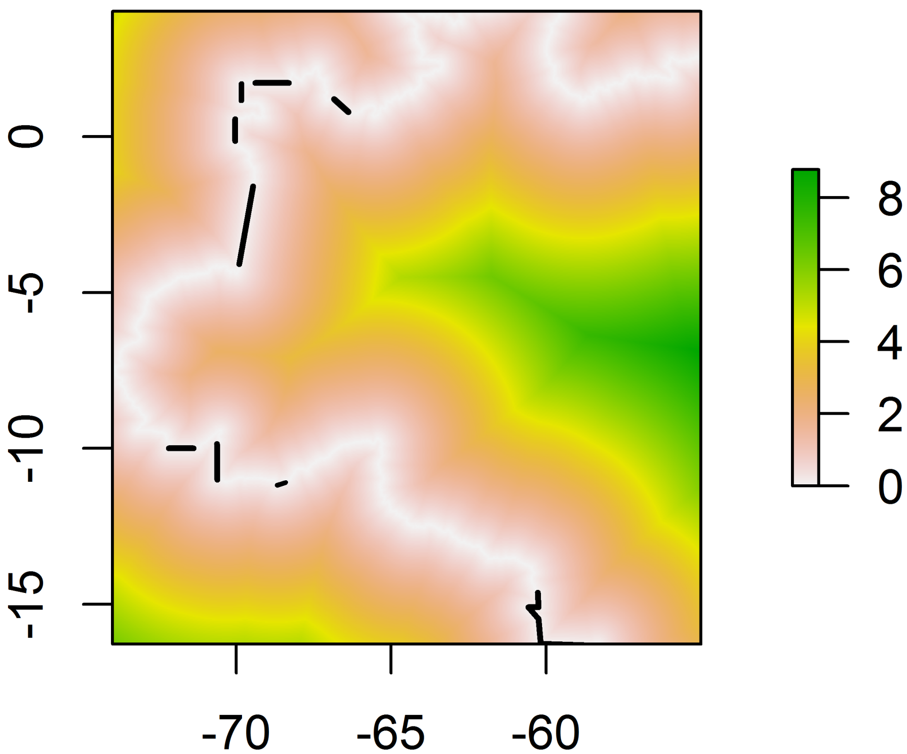


Figure A6: Farmgate Soybean Prices in Brazil and Bolivia

This figure shows average producer prices for soybeans in Brazil and neighboring Bolivia, using data from the FAO.



(a) Map of elevation with 220km radius buffer around the peak of Mount Roraima



(b) Map of Distance From Border with Artificial Borders Highlighted

Figure A7: Maps

The map in the upper panel shows the elevation (in shades as in the scale) with a 220km radius buffer around the peak of Mount Roraima in the North segment of Brazilian border with Venezuela and Guyana. The map in the bottom panel shows the distance from border measures in latitude degrees (in shades as in the scale). The area in white is distance zero. The highlighted sections in black are the areas where the border is artificially delimited, i.e., where borders are not set by a natural landmark.

Table A1: Summary Statistics

	Bandwidth 25km		Bandwidth 100km	
	Brazil	Abroad	Brazil	Abroad
	(1)	(2)	(3)	(4)
# Observations	14,809,321	14,841,401	52,646,804	52,636,853
Forest cover in 2000 (%)	83.30	89.36	84.29	90.37
Forest loss in 2001 (%)	.313	.058	.329	.047
Forest loss in 2002 (%)	.381	.052	.381	.042
Forest loss in 2003 (%)	.312	.049	.322	.037
Forest loss in 2004 (%)	.427	.071	.372	.063
Forest loss in 2005 (%)	.483	.121	.437	.096
Forest loss in 2006 (%)	.197	.071	.223	.059
Forest loss in 2007 (%)	.172	.092	.172	.071
Forest loss in 2008 (%)	.171	.106	.187	.097
Forest loss in 2009 (%)	.145	.112	.153	.088
Forest loss in 2010 (%)	.219	.120	.213	.115
Forest loss in 2011 (%)	.147	.138	.163	.092
Forest loss in 2012 (%)	.186	.107	.191	.105
Forest loss in 2013 (%)	.122	.068	.124	.062
Forest loss in 2014 (%)	.220	.099	.234	.087
Forest loss in 2015 (%)	.184	.077	.201	.071
Forest loss in 2016 (%)	.372	.175	.444	.189
Forest loss in 2017 (%)	.341	.160	.353	.173
Protected Areas (%)	48.2	.8	46.3	.2
Private Non-PAs (%)	14.7	-	18.6	-
Unclaimed Non-PAs (%)	37.1	-	35.1	-
Area in Black Listed Counties (%)	3.0	-	1.5	-
Dist. to enforcement (km)	705.3	741	648.4	788
Dist. to water (km)	44.2	46.1	41.3	38.3
Dist. to urban (km)	89.9	92.9	88.6	92.7
Dist. to roads (km)	40.4	47.2	34.6	50.8
Roads within 5km (%)	14.9	15.1	16.9	12.9
Mount Roraima's Buffer (%)	7.30	7.9	5.2	8.1

This table presents the summary statistics of the variables used in the paper. Each column present results for a different bandwidth or segment of the border in *Brazil* and *Abroad* (bordering countries) as indicated. The bandwidth of 25km is the average optimal bandwidth of our dependent variables. Units of observations are 120-meter pixels around the whole Brazilian Amazon border.

Table A2: Covariates Balance Check – Linear Polynomials

	Land			Distance from								
	Slope			Urban Area			Water			Roads		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A. *Maximum Distance from Border 25km*												
Brazil (γ)	-.014	-.014	-.024	-.001	-.002	-.001	-.003	-.003	-.003	0	-.002	-.001
	(.151)	(.163)	(.138)	(.061)	(.064)	(.066)	(.028)	(.03)	(.031)	(.034)	(.036)	(.036)
Panel B. *Maximum Distance from Border* 11 *km*												
Brazil (γ)	-.105	-.113	-.121	.001	.001	.001	0	0	0	.002	.002	.002
	(.23)	(.25)	(.226)	(.058)	(.061)	(.062)	(.028)	(.03)	(.03)	(.031)	(.033)	(.034)
Panel C. *Maximum Distance from Border* 50 *km*												
Brazil (γ)	-.013	-.013	-.007	-.011	-.011	-.011	-.01	-.014	-.011	-.011	-.015	-.012
	(.102)	(.11)	(.093)	(.061)	(.065)	(.066)	(.027)	(.029)	(.029)	(.034)	(.036)	(.036)
Panel D. *Maximum Distance from Border* 100 *km*												
Brazil (γ)	.046	.05	.066	-.023	-.025	-.028	-.037	-.047	-.039	-.035	-.039	-.045
	(.069)	(.074)	(.065)	(.052)	(.054)	(.056)	(.022)	(.023)	(.024)	(.028)	(.03)	(.031)
Excl. Mount Roraima		Yes			Yes			Yes			Yes	
Artificial Borders			Yes			Yes			Yes			Yes

This table presents the regression estimates of the Brazilian dummy, γ, on land slope (columns 1-3), distance from water (columns 4-6), distance from roads (columns 7-9) and distance from urban areas (columns 10-12), from equation (1) with *linear polynomials*. Panel A refers to the optimal bandwidth of (Imbens and Kalyanaraman, 2012), and Panel B refers to the average optimal bandwidth and bias-correction bandwidth (Calonico et al., 2014) of our dependent variables. Bias-correction bandiwtdh are 53km, 23km, 100km, and 100km, respectively. Units of observations are 120-meter pixels around the whole Brazilian Amazon border. We present results for three segments as indicated in the columns: the whole border, the border excluding a 220km buffer around the peak of Mount Roraima, and artificial borders only. Number of observations (whole border; excluding Mount Roraima; artificial border): Panel A (6,239,668; 5,750,468; 558,906), Panel B (20,537,712; 18,961,163; 2,016,027), Panel C (56,024,296; 51,982,251; 5,029,133), Panel D (105,283,103; 98,296,660; 7,289,279). Standard errors clustered at 25km grids in parentheses, number of clusters for the respective border segments: Panel A (301; 282; 39), Panel B (223; 205; 27), Panel C (510; 480; 58), Panel D (788; 747; 72). Significance levels: *10%, **5%, ***1%.

Table A3: Results Forest Loss by Year

Dep. Variable	Brazil (γ) By Maximum Distance from Border			
	25 km	11 km	50 km	100 km
	(1)	(2)	(3)	(4)
Forest cover in 2000 (%)	-3.893*	-2.822	-4.801**	-5.568**
	(1.92)	(1.713)	(1.965)	(1.683)
Forest loss in 2001 (%)	.105**	.094**	.170***	.216***
	(.038)	(.035)	(.040)	(.038)
Forest loss in 2002 (%)	.216***	.171***	.274***	.295***
	(.060)	(.056)	(.062)	(.053)
Forest loss in 2003 (%)	.204***	.131***	.234***	.227***
	(.050)	(.042)	(.049)	(.041)
Forest loss in 2004 (%)	.221***	.130**	.308***	.331***
	(.062)	(.055)	(.061)	(.052)
Forest loss in 2005 (%)	.200*	.162*	.281***	.330***
	(.088)	(.081)	(.083)	(.071)
Forest loss in 2006 (%)	.044	.056	.080*	.091**
	(.045)	(.044)	(.040)	(.032)
Forest loss in 2007 (%)	.027	-.015	.050	.058
	(.031)	(.030)	(.031)	(.026)
Forest loss in 2008 (%)	-.005	-.043	.030	.040
	(.048)	(.064)	(.038)	(.028)
Forest loss in 2009 (%)	-.049	-.062*	-.021	.011
	(.033)	(.035)	(.030)	(.026)
Forest loss in 2010 (%)	.039	-.022	.080**	.081**
	(.039)	(.042)	(.037)	(.032)
Forest loss in 2011 (%)	-.049	-.049	-.046	-.015
	(.040)	(.032)	(.040)	(.034)
Forest loss in 2012 (%)	.026	.005	.051	.065*
	(.028)	(.027)	(.028)	(.025)
Forest loss in 2013 (%)	.029	-.003	.045**	.046**
	(.02)	(.020)	(.020)	(.017)
Forest loss in 2014 (%)	.073	.025	.085*	.107*
	(.051)	(.073)	(.042)	(.032)
Forest loss in 2015 (%)	.071**	.010	.093***	.090**
	(.031)	(.030)	(.031)	(.025)
Forest loss in 2016 (%)	.119**	.070	.161***	.161***
	(.051)	(.048)	(.050)	(.046)
Forest loss in 2017 (%)	.167**	.092	.174***	.165***
	(.066)	(.052)	(.061)	(.048)
Forest loss in 2018 (%)	.073*	.037	.093**	.116**
	(.035)	(.035)	(.037)	(.033)

This table presents the regression estimates of the Brazilian effect, γ, on the percentage of forest cover in 2000 (row 1) and annual forest loss (remaining rows), from equation (1) with linear polynomials and triangular kernel. All regressions control for the slope of the terrain and distance to water. Each column shows results for a different bandwidth, as indicated. Column 1 refers to the average optimal bandwidth and bias-correction bandwidth (Imbens and Kalyanaraman, 2012) of our dependent variables, and column 2 refers to the optimal bandwidth of (Calonico et al., 2014). Bias-correction bandwidths are 53km, 23km, 100km, and 100km, respectively. Units of observations are 120-meter pixels around the whole Brazilian Amazon border. Standard errors clustered at 25km grids in parentheses. Number of clusters and observations: 1,094 and 31,071,838 (column 1), 708 and 13,871,677 (column 2), 1,660 and 56,024,296 (column 3), 2,759 and 105,283,103 (column 4). Significance levels: *10%, **5%, ***1%.

Table A4: Robustness – OLS Model - Controls - Quadratic Polynomial - Mount Roraima

Dep. Variable	Brazil (γ)			
	(1)	(2)	(3)	(4)
Forest cover in 2000 (%)	-3.949*	-4.566***	-2.906	-9.693***
	(1.977)	(1.647)	(1.776)	(1.799)
Forest loss in 2001 (%)	.105**	.114**	.084**	.313***
	(.038)	(.041)	(.036)	(.036)
Forest loss in 2002 (%)	.217***	.233***	.152***	.53***
	(.061)	(.065)	(.055)	(.058)
Forest loss in 2003 (%)	.205***	.219***	.153***	.452***
	(.05)	(.053)	(.045)	(.048)
Forest loss in 2004 (%)	.222***	.24***	.136**	.553***
	(.063)	(.067)	(.06)	(.06)
Forest loss in 2005 (%)	.2*	.217**	.176*	.502***
	(.088)	(.095)	(.087)	(.085)
Forest loss in 2006 (%)	.045	.05	.04	.141***
	(.045)	(.048)	(.046)	(.044)
Forest loss in 2007 (%)	.027	.029	-.005	.091***
	(.031)	(.033)	(.033)	(.03)
Forest loss in 2008 (%)	-.004	-.006	-.039	.038
	(.049)	(.052)	(.063)	(.047)
Forest loss in 2009 (%)	-.049	-.053	-.066*	-.04
	(.034)	(.036)	(.039)	(.033)
Forest loss in 2010 (%)	.04	.044	-.025	.136***
	(.04)	(.042)	(.044)	(.038)
Forest loss in 2011 (%)	-.048	-.052	-.046	-.054
	(.041)	(.043)	(.039)	(.039)
Forest loss in 2012 (%)	.026	.03	.001	.094***
	(.028)	(.03)	(.028)	(.027)
Forest loss in 2013 (%)	.029	.032	-.007	.082***
	(.02)	(.022)	(.021)	(.019)
Forest loss in 2014 (%)	.073	.081	.032	.187***
	(.053)	(.056)	(.07)	(.051)
Forest loss in 2015 (%)	.071**	.079**	.014	.175***
	(.032)	(.034)	(.03)	(.031)
Forest loss in 2016 (%)	.12**	.139**	.036	.285***
	(.052)	(.054)	(.053)	(.05)
Forest loss in 2017 (%)	.167**	.185**	.114*	.34***
	(.067)	(.071)	(.057)	(.064)
Forest loss in 2018 (%)	.074*	.081*	.043	.189***
	(.036)	(.038)	(.038)	(.034)
Polinomial	Linear	Linear	Quadratic	Linear
Controls	None	Geographic	Geographic	Geo. & Infrastructure
Excl. Mount Roraima	No	Yes	No	No

This table presents the regression estimates of the Brazilian effect, γ, on the percentage of forest cover in 2000 (row 1) and annual forest loss (remaining rows), from equation (1). Bandwidth 25km, bias-correction bandwidth 53km, and triangular kernel as in column 1 Table A3. All regressions, except column 1, control for the slope of the terrain and distance to water. Column 2 uses a subset of the border excluding a 220km buffer around the peak of Mount Roraima. Column 3 uses quadratic polynomials of distance to the border; other columns use linear polynomials. Column 4 further controls for the distance from roads and distance from urban areas. Units of observations are 120-meter pixels. Standard errors clustered at 25km grids in parentheses. Number of observations: 1,094 and 31,071,838 (columns 1, 3 and 4), 1,017 and 28,705,843 (column 2). Significance levels: *10%, **5%, ***1%.

Table A5: Robustness – Artificial Borders - Rectangular Kernel - Poisson Model

Dep. Variable	Brazil (γ)			
	OLS Model		Poisson Model	
	(1)	(2)	(3)	(4)
Forest cover in 2000 (%)	-9.811*	-4.407*	-.047***	-.126*
	(5.363)	(2.069)	(.017)	(.065)
Forest loss in 2001 (%)	.222*	.131**	.989***	1.547***
	(.115)	(.043)	(.221)	(.436)
Forest loss in 2002 (%)	.312	.246***	1.381***	1.854***
	(.187)	(.07)	(.292)	(.554)
Forest loss in 2003 (%)	.426*	.225***	1.531***	1.561***
	(.222)	(.053)	(.224)	(.296)
Forest loss in 2004 (%)	.593***	.263***	1.165***	2.574***
	(.209)	(.066)	(.267)	(.411)
Forest loss in 2005 (%)	.107	.228**	.714***	.341
	(.089)	(.09)	(.217)	(.445)
Forest loss in 2006 (%)	.124	.048	.261	.371
	(.158)	(.046)	(.322)	(.672)
Forest loss in 2007 (%)	.029	.036	.248	.151
	(.108)	(.033)	(.224)	(.427)
Forest loss in 2008 (%)	-.208	.012	-.039	-.703
	(.319)	(.043)	(.204)	(.459)
Forest loss in 2009 (%)	-.205*	-.037	-.299	-1.222**
	(.114)	(.033)	(.21)	(.521)
Forest loss in 2010 (%)	-.144	.076*	.411**	-.236
	(.24)	(.04)	(.209)	(.578)
Forest loss in 2011 (%)	-.101	-.048	-.331	-.61
	(.09)	(.044)	(.259)	(.535)
Forest loss in 2012 (%)	-.014	.043	.267	.049
	(.052)	(.029)	(.184)	(.493)
Forest loss in 2013 (%)	.025	.046**	.463**	.462
	(.073)	(.021)	(.186)	(.695)
Forest loss in 2014 (%)	.019	.086	.351***	.436
	(.042)	(.047)	(.131)	(.419)
Forest loss in 2015 (%)	-.166	.094***	.679***	-.294
	(.138)	(.035)	(.219)	(.499)
Forest loss in 2016 (%)	-.028	.167***	.616***	.613
	(.172)	(.054)	(.178)	(.621)
Forest loss in 2017 (%)	-.237	.187**	.65***	-.334
	(.254)	(.071)	(.232)	(.745)
Forest loss in 2018 (%)	.056	.088**	.494***	.013
	(.175)	(.038)	(.191)	(.618)
Artificial Border Only	Yes	No	No	Yes
Kernel	Triangular	Rectangular	Rectangular	Rectangular

This table presents the regression estimates of the Brazilian effect, γ, on the percentage of forest cover in 2000 (row 1) and annual forest loss (remaining rows), from equation (1) with linear polynomials. Bandwidth 25km and bias-correction bandwidth 53km as in column 1 Table A3. All regressions control for the slope of the terrain and distance to water. Columns 1 and 4 uses a subset of the border to the areas around artificial borders (i.e., straight line borders). Column 1 uses a triangular kernel, other columns use rectangular kernel. Columns 3 and 4 use a Poisson model instead of OLS. Units of observations are 120-meter pixels. Standard errors clustered at 25km grids in parentheses. Number of observations: 1,094 and 31,071,838 (columns 2 and 3), 129 and 3,134,194 (columns 1 and 4). Significance levels: *10%, **5%, ***1%.

Table A6: Heterogeneous Effect by Land Type (Poisson model)

Dep. Variable	Brazil (γ)		
	Protected Areas	Private and Non-Protected Areas	Unclaimed and Non-Protected Areas
	(1)	(2)	(3)
Forest cover in 2000 (%)	.05***	-.383***	-.077***
	(.019)	(.061)	(.029)
Forest loss in 2001 (%)	-.265	2.558***	.63**
	(.411)	(.226)	(.253)
Forest loss in 2002 (%)	-.5	2.943***	.962***
	(.428)	(.314)	(.3)
Forest loss in 2003 (%)	-.204	3.042***	1.158***
	(.492)	(.226)	(.275)
Forest loss in 2004 (%)	-.961***	2.817***	.686**
	(.354)	(.28)	(.299)
Forest loss in 2005 (%)	-1.742***	2.509***	.322
	(.428)	(.229)	(.247)
Forest loss in 2006 (%)	-1.444***	1.576***	.147
	(.423)	(.358)	(.389)
Forest loss in 2007 (%)	-.966***	1.428***	.073
	(.25)	(.264)	(.282)
Forest loss in 2008 (%)	-1.511***	1.201***	-.219
	(.391)	(.256)	(.213)
Forest loss in 2009 (%)	-1.07***	.769***	-.709***
	(.257)	(.269)	(.231)
Forest loss in 2010 (%)	-.018	1.492***	-.029
	(.36)	(.25)	(.24)
Forest loss in 2011 (%)	-1.359***	.693**	-.581**
	(.284)	(.314)	(.278)
Forest loss in 2012 (%)	-.483**	1.534***	-.108
	(.203)	(.265)	(.218)
Forest loss in 2013 (%)	-.822***	1.947***	.18
	(.207)	(.275)	(.198)
Forest loss in 2014 (%)	-.577**	1.411***	.276
	(.282)	(.256)	(.193)
Forest loss in 2015 (%)	-.888***	2.139***	.235
	(.246)	(.293)	(.22)
Forest loss in 2016 (%)	-.252	1.997***	.239
	(.308)	(.216)	(.187)
Forest loss in 2017 (%)	.509	1.577***	.304
	(.456)	(.277)	(.241)
Forest loss in 2018 (%)	-.885***	1.83***	.421*
	(.246)	(.276)	(.223)

This table presents the Poisson regression estimates of the Brazilian effect, γ, on the percentage of forest cover in 2000 (row 1) and annual forest loss (remaining rows), from equation (1) with linear polynomials and rectangular kernel. All regressions control for the slope of the terrain and distance to water. Maximum Distance from Border 25 km. Each column refers to different land types within Brazil. Units of observations are 120-meter pixels. Standard errors clustered at 25km grids in parentheses. Number of clusters and of observations: 980 and 23,043,139 (Panel A), 870 and 17,833,657 (Panel B), 974 and 21,289,806 (Panel C). Significance levels: *10%, **5%, ***1%.

Table A7: Heterogeneous Effect by Country Border (Poisson model)

Dep. Variable	Brazil (γ) By Border Segment				
	Bolivia	Peru	Colombia	Venezuela	Guyana, Suriname, and French Guyane
	(1)	(2)	(3)	(4)	(5)
Forest cover in 2000 (%)	-.271***	-.003	.002	.045**	-.009
	(.046)	(.002)	(.003)	(.021)	(.051)
Forest loss in 2001 (%)	1.199***	.56	-.242	.096	.802*
	(.273)	(.554)	(.373)	(.472)	(.423)
Forest loss in 2002 (%)	1.549***	.4	.175	.456	.676
	(.349)	(.524)	(.312)	(.699)	(.475)
Forest loss in 2003 (%)	1.571***	.463	-.544	1.044*	1.232**
	(.241)	(.485)	(.432)	(.569)	(.491)
Forest loss in 2004 (%)	1.315***	.43	-.115	.091	.279
	(.308)	(.539)	(.408)	(.383)	(.547)
Forest loss in 2005 (%)	.846***	.599	-1.005*	-.289	1.171***
	(.246)	(.482)	(.537)	(.446)	(.408)
Forest loss in 2006 (%)	.357	.146	-.627	.051	.775
	(.387)	(.418)	(.379)	(.512)	(.478)
Forest loss in 2007 (%)	.228	.514	.178	.676**	.566*
	(.275)	(.392)	(.359)	(.309)	(.317)
Forest loss in 2008 (%)	-.062	-.287	-.463	.216	.793**
	(.232)	(.444)	(.437)	(.38)	(.343)
Forest loss in 2009 (%)	-.295	.218	-.909**	.227	.379
	(.257)	(.414)	(.421)	(.446)	(.316)
Forest loss in 2010 (%)	.586**	-.438	-.22	.396	.071
	(.261)	(.407)	(.302)	(.416)	(.283)
Forest loss in 2011 (%)	-.349	.2	-.613	-.193	.183
	(.29)	(.476)	(.495)	(.438)	(.262)
Forest loss in 2012 (%)	.471*	.16	-.812**	.011	.31*
	(.244)	(.39)	(.378)	(.29)	(.174)
Forest loss in 2013 (%)	.861***	.095	-.56	.255	-.724
	(.228)	(.437)	(.384)	(.379)	(.577)
Forest loss in 2014 (%)	.498***	.338	-.757*	.02	-.422
	(.171)	(.386)	(.391)	(.3)	(.267)
Forest loss in 2015 (%)	.896***	.807**	-.504	.046	.305
	(.286)	(.367)	(.385)	(.366)	(.334)
Forest loss in 2016 (%)	.962***	.069	-.353	.344	-.179
	(.268)	(.455)	(.375)	(.5)	(.408)
Forest loss in 2017 (%)	.873***	.327	-.525	.161	-.241
	(.282)	(.407)	(.378)	(.381)	(.364)
Forest loss in 2018 (%)	.845***	.418	-.577	-.141	-.022
	(.248)	(.456)	(.445)	(.337)	(.376)

This table presents the Poisson regression estimates of the Brazilian effect, γ, on the percentage of forest cover in 2000 (row 1) and annual forest loss (remaining rows), from equation (1) with linear polynomials and rectangular kernel. All regressions control for the slope of the terrain and distance to water; bandwidth 25km. Each column refers to results across different country border segments. Units of observations are 120-meter pixels. Standard errors clustered at 25km grids in parentheses. Number of clusters and observations: 275 and 7,670,348 (column 1), 206 and 5,760,641 (column 2), 187 and 5,283,074 (column 3), 196 and 5,497,980 (column 4), and 249 and 6,853,075 (column 5). Significance levels: *10%, **5%, ***1%.

Table A8: Heterogeneous Effect by Distance to Roads (Poisson model)

	Brazil (γ) By Distance to Roads		
	Within 16km	Between 16km and 50km	More than 50km
	(1)	(2)	(3)
Forest cover in 2000 (%)	-.149***	-.042*	.007
	(.044)	(.024)	(.005)
Forest loss in 2001 (%)	1.308***	-.687*	.513
	(.248)	(.372)	(.402)
Forest loss in 2002 (%)	1.566***	.138	.417
	(.325)	(.416)	(.372)
Forest loss in 2003 (%)	1.735***	.181	.938**
	(.246)	(.384)	(.475)
Forest loss in 2004 (%)	1.328***	.305	.257
	(.299)	(.472)	(.435)
Forest loss in 2005 (%)	.867***	-.036	-.117
	(.226)	(.474)	(.742)
Forest loss in 2006 (%)	.411	-.495	.464
	(.364)	(.419)	(.439)
Forest loss in 2007 (%)	.349	-.13	.875**
	(.257)	(.354)	(.358)
Forest loss in 2008 (%)	.008	-.208	.572
	(.217)	(.371)	(.386)
Forest loss in 2009 (%)	-.152	-.988**	.385
	(.236)	(.47)	(.402)
Forest loss in 2010 (%)	.471*	.32	-.299
	(.243)	(.355)	(.474)
Forest loss in 2011 (%)	-.13	-1.36**	.743
	(.289)	(.563)	(.484)
Forest loss in 2012 (%)	.62***	-1.014**	.543**
	(.199)	(.401)	(.229)
Forest loss in 2013 (%)	.807***	-.67*	-.127
	(.199)	(.394)	(.493)
Forest loss in 2014 (%)	.578***	-.434	.397
	(.161)	(.314)	(.488)
Forest loss in 2015 (%)	.882***	-.103	.883*
	(.253)	(.434)	(.458)
Forest loss in 2016 (%)	.742***	-.135	.565
	(.212)	(.343)	(.567)
Forest loss in 2017 (%)	.779***	.332	-.053
	(.269)	(.371)	(.369)
Forest loss in 2018 (%)	.811***	-.631	-.062
	(.214)	(.44)	(.356)

This table presents the Poisson regression estimates of the Brazilian effect, γ, on the percentage of forest cover in 2000 (row 1) and annual forest loss (remaining rows), from equation (1) with linear polynomials and rectangular kernel. All regressions control for the slope of the terrain and distance to water; bandwidth 25km. Each column refers to results across subsamples of pixels in different terciles distance to roads. Units of observations are 120-meter pixels. Standard errors clustered at 25km grids in parentheses. Number of clusters and observations: 505 and 10,356,924 (Panel A), 649 and 10,357,284 (Panel B), 446 and 10,357,630 (Panel C), 447 and 10,356,785 (Panel D), 541 and 10,357,574 (Panel E), and 415 and 10,357,479 (Panel F). Significance levels: *10%, **5%, ***1%.

Table A9: Heterogeneous Effect by Distance to Town or Village (Poisson model)

	Brazil (γ) By Distance to Town or Village		
	Within 41km	Between 41km and 100km	More than 100km
	(1)	(2)	(3)
Forest cover in 2000 (%)	-.113**	-.04	0
	(.045)	(.025)	(.013)
Forest loss in 2001 (%)	.931***	1.168***	.707**
	(.262)	(.375)	(.289)
Forest loss in 2002 (%)	1.469***	.837*	.556*
	(.345)	(.452)	(.295)
Forest loss in 2003 (%)	1.451***	1.787***	.929**
	(.261)	(.315)	(.459)
Forest loss in 2004 (%)	1.107***	1.488***	.358
	(.306)	(.422)	(.286)
Forest loss in 2005 (%)	.557**	1.411***	.518
	(.225)	(.426)	(.325)
Forest loss in 2006 (%)	.081	.967***	.433*
	(.372)	(.358)	(.249)
Forest loss in 2007 (%)	.09	.738**	.705**
	(.258)	(.34)	(.304)
Forest loss in 2008 (%)	-.221	.827**	.17
	(.223)	(.382)	(.298)
Forest loss in 2009 (%)	-.435*	.026	.263
	(.241)	(.433)	(.328)
Forest loss in 2010 (%)	.354	.34	.445
	(.242)	(.412)	(.325)
Forest loss in 2011 (%)	-.363	-.317	.393
	(.286)	(.575)	(.271)
Forest loss in 2012 (%)	.34	.032	.171
	(.212)	(.397)	(.233)
Forest loss in 2013 (%)	.635***	-.099	.058
	(.22)	(.346)	(.354)
Forest loss in 2014 (%)	.412***	.163	-.082
	(.149)	(.322)	(.234)
Forest loss in 2015 (%)	.814***	.22	.461
	(.262)	(.387)	(.295)
Forest loss in 2016 (%)	.619***	.402	.577
	(.212)	(.374)	(.536)
Forest loss in 2017 (%)	.475**	1.199**	.113
	(.236)	(.551)	(.302)
Forest loss in 2018 (%)	.471**	.81**	-.098
	(.222)	(.404)	(.338)

This table presents the Poisson regression estimates of the Brazilian effect, γ, on the percentage of forest cover in 2000 (row 1) and annual forest loss (remaining rows), from equation (1) with linear polynomials and rectangular kernel. All regressions control for the slope of the terrain and distance to water; bandwidth 25km. Each column refers to results across subsamples of pixels in different terciles distance to town or village. Units of observations are 120-meter pixels. Standard errors clustered at 25km grids in parentheses. Number of clusters and observations: 505 and 10,356,924 (Panel A), 649 and 10,357,284 (Panel B), 446 and 10,357,630 (Panel C), 447 and 10,356,785 (Panel D), 541 and 10,357,574 (Panel E), and 415 and 10,357,479 (Panel F). Significance levels: *10%, **5%, ***1%.

Table A10: Heterogeneous Effect by Distance to Enforcement (Poisson model)

	Brazil (γ) By Distance to Enforcement Base		
	Within 565km	Between 565km and 881km	More than 881km
	(1)	(2)	(3)
Forest cover in 2000 (%)	-.16***	.007	.002
	(.034)	(.036)	(.008)
Forest loss in 2001 (%)	1.519***	.422	-.405
	(.305)	(.271)	(.335)
Forest loss in 2002 (%)	1.587***	.819**	-.064
	(.407)	(.322)	(.252)
Forest loss in 2003 (%)	1.807***	.519	-.162
	(.263)	(.321)	(.397)
Forest loss in 2004 (%)	1.522***	.292	-.275
	(.38)	(.342)	(.345)
Forest loss in 2005 (%)	1.189***	.093	-.656
	(.272)	(.265)	(.42)
Forest loss in 2006 (%)	.47	-.355	-.545
	(.445)	(.371)	(.329)
Forest loss in 2007 (%)	.388	.012	.012
	(.301)	(.331)	(.283)
Forest loss in 2008 (%)	.023	-.39	-.489
	(.252)	(.37)	(.344)
Forest loss in 2009 (%)	-.29	.024	-.903**
	(.274)	(.307)	(.386)
Forest loss in 2010 (%)	.58**	.308	-.503*
	(.281)	(.287)	(.275)
Forest loss in 2011 (%)	-.414	.165	-.814**
	(.306)	(.315)	(.365)
Forest loss in 2012 (%)	.39	.484*	-.766**
	(.25)	(.286)	(.318)
Forest loss in 2013 (%)	.737***	.727**	-.814***
	(.26)	(.363)	(.278)
Forest loss in 2014 (%)	.366**	.75***	-.86***
	(.166)	(.269)	(.288)
Forest loss in 2015 (%)	.838***	.809***	-.565*
	(.314)	(.27)	(.298)
Forest loss in 2016 (%)	.929***	.371	-.568*
	(.29)	(.271)	(.298)
Forest loss in 2017 (%)	.851***	.564**	-.708***
	(.313)	(.276)	(.249)
Forest loss in 2018 (%)	.744***	.588**	-.742**
	(.27)	(.299)	(.347)

This table presents the Poisson regression estimates of the Brazilian effect, γ, on the percentage of forest cover in 2000 (row 1) and annual forest loss (remaining rows), from equation (1) with linear polynomials and rectangular kernel. All regressions control for the slope of the terrain and distance to water; bandwidth 25km. Each column refers to results across subsamples of pixels in different terciles distance to enforcement base. Units of observations are 120-meter pixels. Standard errors clustered at 25km grids in parentheses. Number of clusters and observations: 505 and 10,356,924 (Panel A), 649 and 10,357,284 (Panel B), 446 and 10,357,630 (Panel C), 447 and 10,356,785 (Panel D), 541 and 10,357,574 (Panel E), and 415 and 10,357,479 (Panel F). Significance levels: *10%, **5%, ***1%.

B Additional Background Information

B.1 Timeline of Relevant Events in the Brazilian Amazon and Brazilian Environmental Policy

1494	Treaty of Tordesillas, most of the Amazon belongs to the Spanish Crown.
1637	First big Portuguese expedition to the Amazon (two thousand people).
1750	Treaty of Madrid, Portugal gains control of most of the current Brazilian Amazon.
1851-1871	The precise limits of Brazilian border with Bolivia and Peru are set.
1870-1900	First Rubber Cycle. Government gave incentives to migrate to the region. First big migration influx. Migrants could work as rubber tappers, but could not own land.
1904	Brazil gains control of Acre state, in the border with Bolivia and Peru. Last borders defined in Treaty of Rio de Janeiro in1909.
1940-1945	Second Rubber Cycle (coincides with WWII). President Getulio Vargas promotes the "March to the West" and advertises the "New Eldorado".
1964-1980s	Military Dictatorship promoted the occupation of the area.
1976	Regularization of land titling for properties under 60 thousand hectares that were occupied illegally but in "good faith".
1978	Population in the Legal Amazon 7 million people.
1980s	Environmental concerns start to emerge and the main local environmental leader, Chico Mendes, is murdered in 1988.
1990s	New large population influx with cattle ranching and soybean plantations expansion.
2000	Population in the Legal Amazon 21 million people.
2002	The Amazon Protected Area Program (ARPA) is created to expand the Brazilian National System of Protected Areas (SNUC) and to guarantee financial resources to promote sustainable development (Federal Decree 4.326/2002).
	Creation of Ecological and Economic Zoning, EEZ, (Federal Decree 4297/2002).
2003	The first presidential mandate of Lula da Silva begins. Marina Silva is appointed Minister of the Environment.
	The rural caucus in congress (the "ruralists") win 73 seats (14% of the congress).
2004	In November, the Ministry of Environment launches the first phase of PPCDAm.[17]

[17] The first phase was originally planned to be implemented from April 2003.

2004-08	Demarcation of the perimeter of new Conservation Units and Indigenous Lands; both are *Protected Areas*.[18]
	Banning of over 60,000 illegal rural property titles.
	Development of the remote-sensing system DETER by INPE.
2005	Demarcation of Conservation Units in the areas surrounding the highways BR-319 (Manaus – Porto Velho) and BR-163 (Tenente Portela – Santarém).[19]
2005-07	Georeferencing of more than 10 million hectares of public lands in black listed municipalities (none on the border).[20]
2005-07	18 operational basis from IBAMA are constructed.[21]
2006	Law on Public Forest Management (law 11.284/2006) enacted.
	IBAMA's Center for Environmental Monitoring (CEMAM) fully functioning and operational centers receiving online deforestation data.
2007	Begins the second presidential mandate of Lula da Silva.
	First *Black Listed* municipalities are defined (Decree 6.321/2007).
	Ecological and Economic Zoning (EEZ)'s project for BR-163 completed.
	The rural caucus in congress (the "ruralists") win 116 seats (22% of the congress)
2008	Decree 6.514/2008 reestablished the directives to investigate and punish environmental infractions. It defines the administrative processes for environmental crimes, and introduced new mechanisms for law enforcement (e.g., seizure of equipment used for illegal activities).
	Creation of the Sustainable Amazon Plan (PAS) with the aim to define guidelines for sustainable development in the region. This is an strategic plan focused on economic and environmental development of the region, prioritizing the creation of jobs and income for the local population.
	Marina Silva resigns as minister five days after the PAS was released, given the "difficulties that she had been facing to advance with the environmental agenda in the federal government."[22]
	Implementation of "Operation Fire Arc" through public security actions.

[18] Creation of 46 PAs (24 mi ha).
[19] Law 11132/2005.
[20] Altamira, Anapu, Novo Progresso, Medicilândia, Santarém, Esperança, Pacajá, Cachoeira do Piriá, Coroaci-Paraná, and Alto Alegre
[21] An operational base a local headquarters that centralize the local PPDCAm actions in the area.
[22] Extract from the resignation letter: https://noticias.uol.com.br/ultnot/2008/05/13/ult23u2297.jhtm

2008-10	"Operation Green Arc", supported by eight Federal Ministries (Agriculture, Agrarian Development, Environment, Cities, National Integration, Labor, Justice, and Health) instituted policies and actions to promote sustainable development in 43 *black listed municipalities.*
	Resolution conditioning the concession of rural credit in the Amazon Biome upon legal and environmental compliance.[23]
2009	Land titles of federal public land given to squatters with smallholdings.
	Seven municipalities added to the list of black listed municipalities.
2010-15	Second phase of Amazon Protected Area Program (ARPA), with the goal to create 13.5 million ha of new PAs.
2011	The first presidential term of Dilma Rousseff begins.
	The rural caucus in congress (the "ruralists") win 142 seats (28% of the congress)
	Seven municipalities added to the list of black listed municipalities.
2012	New Forest Code (Law 12.651/2012) grant amnesty for small properties (440 ha or less) that had deforested the Legal Reserve area in their properties before 2008.
	Law 12.615/2012 institutes the Environmental Rural Registry (CAR), a mandatory registration for all rural properties.
	The number of IBAMA's enforcement officers is reduced by 13.1% relative to 2010.
2013	The Prosecutor General of Brazil contested the constitutionality of 23 items of the New Forest Code, among them the amnesty for past deforestation.
	Massive social mobilizations all over the country.
2014	Election year, and "Car Wash" operation.
	The number of IBAMA's enforcement officers falls by 24% relative to 2010.
	IBAMA's budget cut by 34.2% relative the previous year.
2015	The second presidential term of Dilma Rousseff begins.
	The rural caucus in congress (the "ruralists") win 207 seats (38% of the congress)
	GDP shrinks 3.7%.
2016	Impeachment of Ms. Rousseff. Begins the presidential mandate of Michel Temer.
	GDP shrinks 3.5%.

[23] Resolution 3545, introduced by the Brazilian National Monetary Council (CMN).

IBAMA lose additional 3.5% of enforcement officers and 13.5% of its budget (relative to 2014).

2017 Law (no. 3.465/2017) simplifies the requirement for land regularization and titling of occupied public land in rural and urban areas.

2018 The Supreme Court sanctioned the New Forestry Code, including the amnesty item.

B.2 Timeline of Relevant Policy Changes in Neighboring Countries

B.2.1 Bolivia

1996 Bolivia Forest Law (No. 1700) regulates the use of forest resources with guidelines for forest management plans (Supreme Decree 24453).

1997 Creation of Bolivian Forestry Superintendent (*Superintendencia Forestal*) to enforce the Forest Law. Decree declaring that the land rights of indigenous communities have precedence over concession-holders' rights.

2008 The National Holistic Forest Management Plan sets the initial ideas of President Evo Morales forest policy. Creation of economic and financial incentives for Community Forest Organizations (*Organizaciones Forestales Comunitarias*, OFC) to comply with forest management plans (Supreme Decree 29643).

2010 The Rights of Mother Earth Law (No. 071) declares Mother Earth the titleholder of inherent rights of the land. The new law promotes resource nationalism, and opposes the commodification of nature. National Program of Forestation and Reforestation created (Supreme Decree 0443). Bolivia politically rejects REDD+.

2012 Revision of and creation of legal framework for Law of Rights of Mother Earth (No. 300).

Proposes the Joint Mitigation and Adaptation Mechanism as an alternative to REDD++.

2013 ABT Resolution 250 outlines the requirement for Forest and Land Holistic Management Plans (PGIBT).

B.2.2 Peru

2001 2001 Forests and Wildlife Law (No. 27308) set first regulations for sustainable use of forest and wildlife resources.

2004 National Forest Strategy is made official. Alto Purus national park established on part of Brazilian boarder.

2010 Action Plan for Adaptation and Mitigation Against Climate Change describes policy proposals in relation to climate change.

2011 New Forests and Wildlife Law (No. 29763) set the fundamental rights and duties related to forest inventory. National parks and conservation areas are "national patrimony." Law suspended waiting for accompanying regulation.

2014 Approval of the Mechanisms of Compensation for Services to Ecosystems (No. 30215).

2015 Final decrees approved setting the norms governing New Forests and Wildlife Law (No. 29763), which is effectively enacted the National Policy for Wildlife and Forests (PNFFS).

2016 The National Forestry and Climate Change Strategy is released, providing an unifying plan and policy objectives for mitigation and adaptation of climate change.

The Action Plan on Gender and Climate Change was approved (Executive Decree No. 012-2016-MINAM).

2018 Approval of the Framework Law on Climate Change (No. 30754/2018).

B.2.3 Colombia

1959 Law 2 introduced environmental planning and established the *Zonas de Reserva Forestal* (ZRF).

1974 The Natural Resource Code (Decree 2811) defines different uses for forest areas.

1993 Law 99 established the National Environmental System (*Sistema Nacional Ambiental*/SINA) and the Ministry of Environment and Sustainable Development (*Ministerio de Ambiente y Desarrollo Sostenible*/MADS). Law 70 gives afro-Colombian communities the right to the sustainable use of natural resources without the need of a license.

2000 Definition of the current National Forestry Policy (CONPES 3824 of 1996, and PNDF of 2000), with emphasis on zoning forest areas by permitted use, and sustainable use as a method of conservation.

2006 New General Forestry Law (*Ley General Forestal*) enacted in 2006 but declared unconstitutional in 2008. Environmental organizations criticized the new law for weakening timber licensing and transportation requirements.

2010 Decree 622 of 1977 established the national scheme of protected areas. Decree 2372 of 2010 created the National Parks Authority.

2011 National REDD+ Strategy are part of President Santos Government's National Development Plan and were enacted into law (Law 1450).

2012 The Colombian Low-Carbon Development Strategy (ECDBC) launched aimed at promoting efficient low-carbon growth.

2013 Decree 953 from May 2013 established the first scheme for payment of environmental services (PES) in Colombia for the protection of water sources.

2014 FARC declares ceasefire following the peace negotiations started in 2012.

2018 Definition of the guidelines for the management of climate change (Law no. 1931) and publication of the Green Growth Policy strategic plan.

B.2.4 Guyana

1998 Forests Act regulates the cutting and removal of forest produce.

2007 Creation of the Guyana Forestry Commission to develop forest policy, enforcement, and certification of forest products.

2009 Low Carbon Development Strategy (LCDS) outlines an action plan to enable the transition of the country to a low-carbon economy.

2010 Enactment of The Forests Act (No. 6/2009), which repeals the 1998 Forests Act. Creates Protected Areas and sets a framework for land use regulation.

2011 Creation of the Guyanese National Forest Plan to implement the Forests Act 2009.

2017 Approval of the framework document for the Guyana Green State Development Strategy, which build on LCDS form 2009.

B.2.5 Suriname

1992 The Forest Management Act sets the requirements for the production and export of timber and non-timber products.

2006 National Forest Policy approved in the scope of the Forest Management Act, regulating both economic activity and land use.

2009 Interim strategic action plan to strengthen sustainable forest management, creating the Environmental Assessment Guidelines for logging, mining, and agriculture. However, an environmental impact assessment is mandatory.

2015 The National Climate Change Policy, Strategy and Action Plan launched outlining the government strategy on climate change mitigation and adaptation until 2021.

B.3 Background

B.3.1 Environmental Regulation in the Brazilian Amazon

Until the 1960s, the Brazilian Amazon's native vegetation was largely preserved and inhospitable, popularly known as the "Green Hell" (*Inferno Verde*). The area had a small and sparse population living at subsistence levels, primarily involved in the extraction of rubber, as well as an indigenous population. Between 1964 and 1985, the military government promoted the occupation of the region by non-indigenous people with large infrastructure construction projects – e.g., by building roads and hydroelectric power plants – and by promoting the titling of occupied productive land (Pfaff, 1999). Consequently, a substantial number of migrants moved to the Amazon area, creating a boom of cattle ranching in the region.

Environmental consequences were not a central concern of Brazil during this period. Indeed, the Ministry of Environment (MMA) was created only in 1985, and the Brazilian Environmental Protection Agency (IBAMA) only in 1989. Even after the creation of IBAMA, and despite the enactment of the first Environmental Crimes Act in 1998, penalties for deforestation and squatting on unclaimed land were weak, and there was little coordination among federal agencies attempting to enforce these laws. On net, between the 1980s and 2004, the deforested area grew from 6% to 16% of total forest land in the Brazilian Amazon (MMA, 2013).

B.3.2 The Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm)

The government of president Lula da Silva brought a new light to the environmental agenda in 2003, with the appointment of Marina Silva as Minister of the Environment. In 2004, the Brazilian federal government launched the *Action Plan for the Prevention and Control of Deforestation in the Legal Amazon* (PPCDAm) to crack down on deforestation in the Amazon. PPCDAm led to changes in both the legal sanctions for deforestation, as well as substantial changes in the enforcement of environmental regulation. In particular, a new remote-sensing system for environmental monitoring and enforcement was created (DETER), which in turn fed coordinated enforcement actions between many government institutions (see more details in Assunção et al., 2013).

In sum, while the vast majority of deforestation in the Amazon was illegal prior to 2005, the *de jure* legal sanctions associated with deforestation substantially increased in 2005.

Yet despite all the migration and infrastructure policies supported since the military government, and despite all the recent enforcement measures promoted by the PPCDAm, the deep Amazon – the area we study in this paper – is still very much a frontier region. Cattle ranchers and illegal loggers are still active. "At the end of the road, on the Amazonian frontier, it feels like the Wild West, except with motor bikes and cell phones," wrote the Vice President and Chief Scientist of WWF, Jon Hoekstra, back in 2010.[24] In an interview to the New York Times in 2014, a top official of IBAMA, Luciano Evaristo, said about one county black listed

[24] http://blog.nature.org/conservancy/2010/05/18/stopping-deforestation-on-the-amazonian-frontier/

by the government, Novo Progresso (literal translation *New Progress*): "this is the Wild West of environmental crimes. We are waging an endless war."[25]

B.3.3 The second reversal

The driving forces of the reversal we observe starting in 2014 cannot be mapped to a single policy or *de jure* regulatory change. Brazilian environmental governance was undermined over the years since 2011 by the growing political power of the agriculture producers, consecutive weak governments and scarce public resources.[26]

Political support for the environmental agenda. The loosening of environmental agenda began in 2011 with President Rousseff's first mandate. The new government adopted a more conservative environmental position relative to the previous year, with a greater focus on promoting economic development through large investments in infrastructure.[27] As Viola and Franchini (2017, Ch. 5) describes, the "Rousseff administration displayed a visible neglect for forest-related and environmental issues". The growing political power of the "ruralists" – i.e., the rural caucus of Congress (Rochedo et al., 2018) – also contributed to the reduced political will to sustain and advance the environmental agenda of the previous years. The number of congressmen in the "ruralists" caucus had grown to 142 in the 2011-2014 legislature – 28% of the seats – from 116 and 79 in the previous two legislatures. The ruralists continued to grow and to push an environmental deregulation agenda in 2015, when this political group elected 207 congressmen – 38% of the Congress (Crouzeilles et al., 2017; Freitas et al., 2018)

Background economic and political turmoil. The widespread social mobilizations in 2013 set the government in crisis, which was fired with a series of corruption scandals involving all levels of the Workers Party administration (Viola and Franchini, 2017). As 2014 was an election year, the government increased public spending to gain the popular support needed for re-election. These economic measures helped re-elect Ms. Rousseff but deteriorated the fiscal situation of the federal government, setting the country in its worst economic crisis ever. Brazilian GDP shrank by 3.7 % in 2015 and by 3.5 % in 2016. Unemployment rate surged quickly. The focus of the federal government shifted to control the economic crisis and the consequences of the corruption scandals. In such unstable political scenario, Ms. Rousseff was impeached by the congress in 2016. The new president Michel Temer was the former vice-president and also involved in the alleged corruption schemes. With very thin public support, the new president had to accommodate the demands from his supporters in congress, in particular, the ruralist caucus.

Environmental regulation. As consequence of this political shift, the congress approved

[25] http://www.nytimes.com/2014/10/04/world/americas/brazil-rainforest-amazon-conservation-election-rousseff-silva.html?_r=0

[26] See, e.g., Tollefson (2016); Fearnside (2016); Viola and Franchini (2017); Crouzeilles et al. (2017); Rochedo et al. (2018); Freitas et al. (2018); Soterroni et al. (2018); Tollefson (2018).

[27] Still in President Lula's government, Ms. Rousseff had an investment agenda to promote growth (*Plano de Acelera;'ao do Crescimento*, PAC) and was an antagonist of Ms. Marina Silva, the Minister of Environment who led PPCDAm. Ms. Silva eventually left the government and the Workers Party, while Ms. Rousseff was chosen the Workers Party's candidate on the 2010 presidential election.

of the New Forest Code (FC) in 2012 – Law 12.651/2012. This is the main change in environmental regulation in the period. The revised FC had many controvert points, one of them the forgiven of "small" properties (those with less than 440 ha in the Amazon) that had deforested before 2008 beyond the maximum allowed by PPCDAm. This effectively would give amnesty to illegal deforestation inside private properties for 90% of Brazilian rural properties, with potential impact of reducing the Brazilian environmental debt by 58% (Soares-Filho et al., 2014). Another contested point, the authorization of exploitation of Areas of Permanent Protection (APP), such as riparian zones, was decentralized from the federal to the state governments. The constitutionality of different items of the new FC were contested in the Supreme Court already in 2013. The FC stayed under analysis until 2018, when the Supreme Court sanctioned the New Forestry Code, including the amnesty item. After 2012, congress made repeated efforts to undo key aspects of the regulatory framework – for example, the revoke of protected areas, and the discontinuation of environmental licensing for infrastructure projects (PEC 65). In 2017, the congress approved a law (no. 3.465/2017) simplifying the requirements for land regularization and titling of occupied public land in rural and urban areas. Rural smallholders that settled in unclaimed lands before December 2016 could obtain land title for free, while larger properties had the option to pay for the land title.

Enforcement capacity. The resources available to IBAMA (the Environmental Regulatory Agency) to enforce environmental regulation were trimmed over the years. An audit from the Office of the Comptroller General (CGU, 2016) document that the number of IBAMA's enforcement officers fell 13.1% between 2010 and 2012, and fell 24% between 2010 and 2014. The report also attend that the officers still working in 2016 tend to be older – 38% of them had been working at IBAMA for more than 30 years. Figure A8 also shows that the budget of IBAMA was cut by 34.2% between 2013 and 2014. During the two years of Ms. Rousseff second mandate, IBAMA's budget was cut additional 13.5% relative to 2014. In 2016, the budget of IBAMA was 57 percent of its budget in 2013.

Thus, more than the *de jure* impact of the new FC, the "amnesty afforded by the new FC could lead to the perception that illegal deforesters are unlikely to be prosecuted and may even be exonerated in future law reforms" (Soares-Filho et al., 2014, pg.364). This perception should have been reinforced by the deterioration of enforcement apparel. Although it is difficult to map how the New Forest Code or the constrained enforcement capacity of IBAMA affected deforestation in each type of land, our results in Figure 5b indicate a trend reversal starting in 2012 specially in private properties and unclaimed lands. The average point estimate of the differential impact of Brazilian policies in private properties that abut the national borders is 81% larger in the 2014-2018 period than in 2009-2011.

B.3.4 The formation of the Brazilian border

Since we focus on the Brazilian border, it is useful to understand briefly the history of how the border was drawn. The broad limits of the Brazilian territory were defined in the colonial period when the Portuguese and the Spanish Crowns had very limited knowledge about the

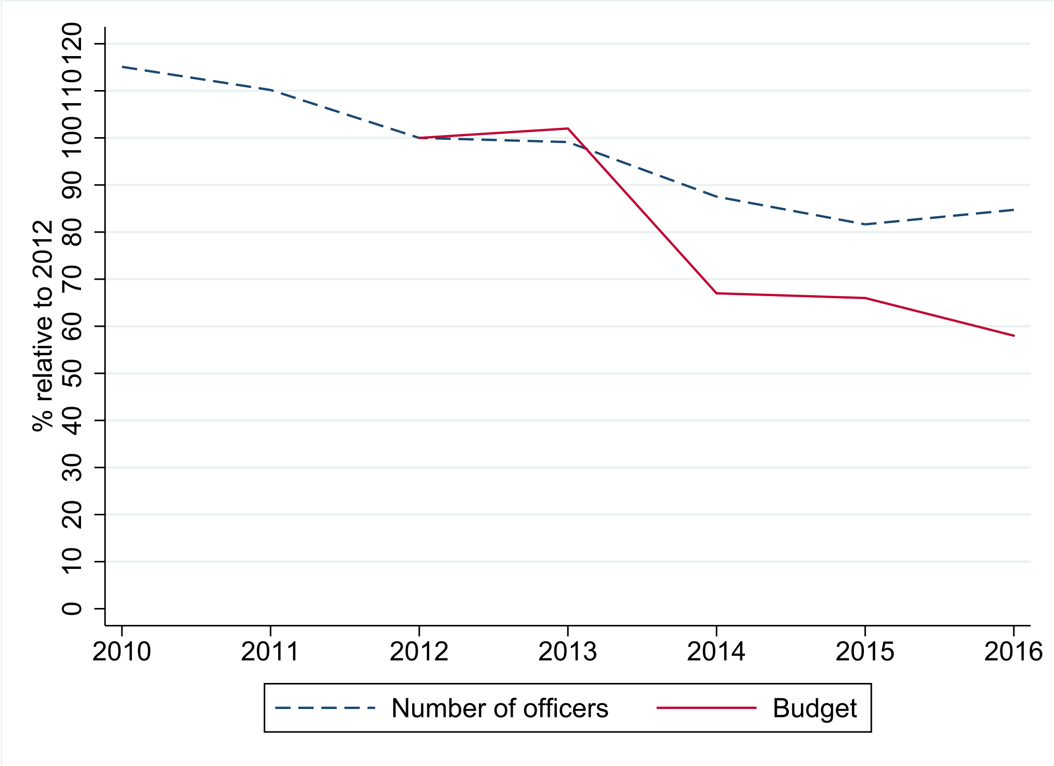


Figure A8: IBAMA's budget and number of enforcement officers over time(CGU, 2016)

precise geography of the center of the South American continent. As such, they usually do not correspond to major differences in economic opportunity – and as we will see, include many arbitrary straight-line segments.

The Treaty of Madrid defined the general lines of the Portuguese – Brazilian – border with the Spanish colonies in 1750. When drawing the Treaty of Madrid map, Portugal and Spain agreed on two general guidelines: (i) who had first established local presence should keep the area (*uti possidetis*); (ii) rivers should be used as border divisions as much as possible to easy demarcation. The main objective of Portugal during the negotiations was to hold the control of the (known) mining regions located between the center of the continent and the Atlantic coast, pushing the border West to keep potential invaders away. The main objective of the Spanish crown was to maintain navigable access to the sea. As such, the Treaty of Madrid set the limits of the colonies in that region would be defined by the Paraguay and Guaporé Rivers, which are located more than 200km and more than 500km, respectively, from the Portuguese westernmost important settlement, Cuiabá.

At the time, in the middle of the 18th century, the areas in the center of the South American continent – and which form the borders we study today – were still largely unknown. This was particularly true for the Amazon area and the Northern segment of the Brazilian border. Indeed, the magnitude of this "unknown" land can be seen by the vast blank spaces in the base map used in the Treaty of Madrid: *Carte de l'Amérique Méridionale*.[28] In fact, the precise location of rivers' springs and mouths – and what was between them – was not exact. The straight-line

[28] "[The] *Carte de l'Amérique Méridionale shows, with great detail and many new local circumstances, the empty state of our knowledge with large completely naked spaces"* (D'Anville (1779)).

segments we can see in the Brazilian border are a consequence of this lack of information. These are due to rivers that followed a different path than the predicted one or that ended before reaching other geographic feature – and in such cases, the Treaty of Madrid (and the subsequent 1867 Treaty of Ayacucho) specified that a straight line should be used instead.[29]

[29] Article VI of the Treaty of Madrid says "... and, from there, seek the straight line by higher ground to the main head of the more nearby river, which flows into the Paraguay River for its Eastern bank, which *might* be what they call Corrientes." The Treaty of Ayacucho (1867) that defined the precise border between Brazil and Bolivia, more than 100 years later, writes: "This river to the West follow the border by a parallel, taken from the left bank in South latitude 10º 20' until you find the Javary River. *If* Javary River has its sources North from this East-West line, follow the border, from the same latitude, for a line to get the main source of said Javary.".