The Political Origins of Deforestation in the Brazilian Amazon, 2000-2012

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Abstract

What accounts for subnational variation in deforestation in the Brazilian Amazon? Using satellite imagery data and a novel shift-share instrumental variable design, I explore how local political competition explains this variation. I show that municipal political competition causally increases deforestation, especially in the presence of more private commercial interests that deforest. I argue that competition encourages mayors to pursue the strategic non-enforcement of environmental standards to cater to such interests. Drawing on qualitative interviews and administrative data on bureaucratic appointments, I show that to achieve this end, mayors use a strategy I term "bureaucratic packing," a surge in appointments of new personnel, to bypass existing personnel who may not aid the mayor's agenda. In contrast to existing theories on the use of appointments for rewarding patrons, the analysis spotlights "bureaucratic packing" as an understudied strategy used to weaken regulatory capacity. Political competition generates incentives for undermining bureaucratic capacity to allow deforestation.

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1 Introduction

Global deforestation, a threat to biodiversity and a driver of climate change, results from the over-extraction of timber and the excessive conversion of forest to agricultural land. Much of the literature on the causes of deforestation places a heavy emphasis on market-based mechanisms with little regard for the role of politics in curbing deforestation. Although the *tragedy of commons* and the role of communal institutions in preventing it has been a key concept in Political Science (see Ostrom (1990)), the political incentives behind natural resource depletion have received limited attention. Despite the large literature on the impact of specific environmental policies, there is a much more limited literature on the political institutions that shape environmental protection. Can institutions explain patterns in managing the environment? Why do some local jurisdictions see rapid deforestation, while others nearby effectively avoid such environmental degradation?

In this paper, I examine the ways in which the institution of local political competition, in particular, affects deforestation in Brazil, which houses the largest remaining tract of tropical rainforest in the world. I argue that politicians concerned with winning the margins under high political competition are pressured to forsake forest cover in the Amazon to cater to private commercial interests that profit from deforestation. Beyond this claim, which is consistent with existing theory, the focus of the paper is on delineating the consequences of these political incentives. Specifically, I argue that mayors facing competitive elections pursue the strategic non-enforcement of environmental standards. Drawing on qualitative evidence from semi-structured interviews, I illustrate the ways in which in their efforts to weaken enforcement, mayors engage in "bureaucratic packing," a surge in appointments of new municipal personnel who are partial to the mayor's agenda. As a strategy, "bureaucratic packing" allows the mayor's cabinet to bypass working with long-serving bureaucrats or to relax enforcement directly through the appointment of new leadership. Such bouts of bureaucratic expansion, therefore, undermine the role of existing personnel in municipal and state secretariats. Using the example of deforestation in the Brazilian Amazon, the argument illustrates the ways in which local political competition, in encouraging forbearance in the enforcement of regulatory standards, in turn generates incentives to weaken bureaucratic capacity.

Using satellite-based spatial deforestation data for the 783 municipalities in the Brazilian Ama-

zon between the years 2000-2012, I test the theory by systematically examining the effects of local political competition on sub-national patterns of deforestation. I estimate panel regressions with municipal- and state-year fixed effects, conducting a placebo test that confirms the causality of the effects: competitive elections induce deforestation, and not vice versa. To further confirm the causality of the effect, I adapt a novel strategy proposed by Shaukat (2019) for causally estimating municipal political competition to a setting of coalitional party structures that characterizes sub-national politics in Brazil. Specifically, I construct a shift-share instrumental variable (SSIV) for political competition in municipal elections, using the competitiveness of elections at higher levels of government as the "shifts."

Contrary to accountability models of competitive elections, I first find that political competition causally increases the rate of deforestation in Brazilian municipalities. I then show that this positive effect of political competition on deforestation is magnified in municipalities with more private agricultural organizations, providing evidence for the claim that political competition generates incentives to cater to private commercial interests. Next, I show that prominent alternative explanations for deforestation, such as municipal economic development, the expansion of road infrastructure, and the level of land inequality cannot explain the results. Using census data on occupation and public opinion survey data from LAPOP, I also confirm that the median resident (i.e., "median voter") in the Amazon is not employed in industries that deforest and prioritizes conservation over other key policy issues, such as economic growth. Moreover, the results hold even in models accounting for the mayor's or state governor's partisanship, suggesting that political alignment across levels of government are not driving the results. Last, I demonstrate that federal monitoring of local governments and policies, such as the environmental embargo (IBAMA) program, the protected areas (PA) program, and the Priority Municipalities (PM) monitoring program, cannot explain the results.

The idea that competitive elections may cultivate perverse political incentives is not a new one. A growing literature argues that political competition in developing democracies can induce pork barrel politics, clientelism, and corruption (Kitschelt and Wilkinson, 2007; Grzymala-Busse, 2007; Calvo and Murillo, 2012; Weitz-Shapiro, 2014; Min, 2015; Herrera, 2017), reduce the efficiency of legislative bargaining (Gottlieb and Kosec, 2019), or induce patronage politics (Pierskalla and

Sacks, 2020). I build on this literature and, instead, illustrate a different consequence: "bureaucratic packing." While rent-seeking and patronage may be simultaneously at play, I argue that competitive elections incentivize politicians to make also mass bureaucratic appointments for the purpose of undermining enforcement capacity and bypassing existing bureaucratic procedures. Bureaucratic appointments are, therefore, often not used as an end in itself to reward one's patrons, but rather are used as a means to an end. I illustrate this mechanism using qualitative evidence from semi-structured interviews. To test the mechanism systematically, I calculate measures of the timing of municipal bureaucratic appointments using a comprehensive data set of public employment labor contracts available from Brazil's Ministry of Labor and Employment. The analysis confirms that political competition results in a surge in the appointment of new municipal personnel within 12 months after a competitive election, and such "packing" is, in turn, negatively associated with deforestation.[1]

This paper contributes to the growing literature on the politics of deforestation, and its emphasis on the role of the sub-national political context (Bates, 1979; Boone, 2003; Morjaria, 2012; Boone, 2014; Buntaine, Hamilton, and Millones, 2015; Herrera, 2017; Pailler, 2018; Milmanda and Garay, 2019; Alcañiz and Gutierrez, 2020; Baragwanath and Bayi, 2020; Gulzar, Lal, and Pasquale, 2020) as well as that on the relationship between regime type and environmental protection (Midlarsky, 1998; Li and Reuveny, 2006; Bernauer and Koubi, 2009; Klopp, 2012; Aklin and Urpelainen, 2013; Sanford, 2021).[2] It also builds on the growing literature on the contradictory effects of political competition (Pierskalla and Sacks, 2020; Gottlieb and Kosec, 2019; Brierley, 2021; Huber and Ting, 2021) and that on the political incentives behind bureaucratic appointments (see, for example, Dahlström and Lapuente (2017); Gulzar and Pasquale (2017); Oliveros and Schuster (2018); Hassan (2020); Brierley (2021); Huber and Ting (2021); Oliveros (2021)).[3]

The paper makes two contributions to these existing literatures. First, whereas existing work presents contradictory evidence on whether democracy at the country-level is positively or negatively *correlated* with the environment, this paper makes an empirical contribution in causally

[1] Politicians engage in "packing" especially when removing existing personnel proves difficult. I find that competitive elections are not associated with bureaucratic *dismissals*.
[2] Suggestions for additional citations are most welcomed.
[3] Suggestions for additional citations are most welcomed.

estimating the effects of a local democratic institution on environmental management. Besides the direction of the theorized effect, the paper also builds on existing work by, instead, spotlighting the mechanism through which this effect occurs. Second, this paper makes a theoretical contribution: it demonstrates that political competition can generate incentives to weaken bureaucratic capacity. Research on patronage politics highlight how bureaucratic weakness is an unintended consequence of when politicians use new appointments to reward individuals for their electoral support. In contrast, this paper illustrates the concept of "bureaucratic packing," the use of new appointments with the intention to undermine bureaucratic capacity, as an understudied strategy in the literature. Existing theories also point to the ways in which bureaucratic capture by vested private interests directly undermine bureaucratic capacity. This paper illustrates that even without bureaucratic capture, subnational executives can circumvent existing bureaucrats through a process of bureaucratic expansion. The findings confirm that the same political institution that democratic theorists view as being critical for public goods and service delivery also induces environmental degradation through the weakening of regulatory capacity.

2 Deforestation in the Brazilian Amazon

Between 1970 and 2010, approximately 18% of the Brazilian Amazon was deforested. After the Lula administration implemented a series of federal policies for protecting the Amazon, the country did experience a dramatic decline in deforestation since 2004. However, federal policy cannot explain the extensive variation in deforestation *within* the country during this period. As shown in Figure 1, there is considerable variation in the pace and extent of deforestation across municipalities within even the same regions in the Amazon. In the state of Pará, the municipality of Paragominas is an oasis of conservation (i.e., 54.7 percentage points in cumulative deforestation by 2012) in a sea of municipalities plagued by forest degradation (i.e., 72.4 percentage points per municipality on average for the region). In a similar vein, within the state of Maranhão, the municipalities of Centro Novo do Maranhão and of Amarante do Maranhão both have venerable track records of conservation. Total cumulative deforestation by the year 2012 for Centro Novo do Maranhão and Amarante do Maranhão were 35.4 and 37.8 percentage points, respectively, in comparison to an average of 67 percentage points across other municipalities the state.

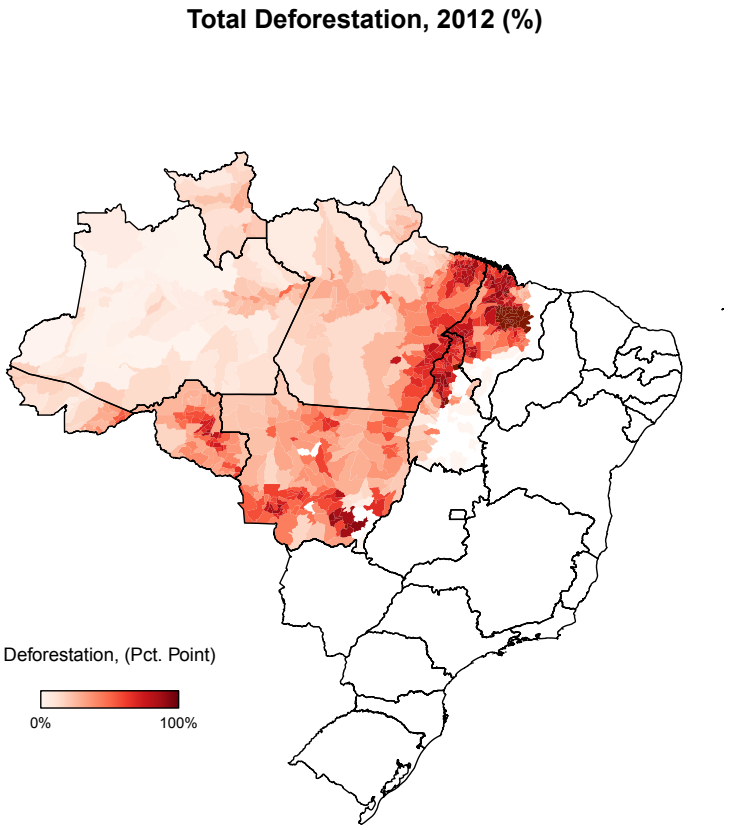

Figure 1: This map shows the spatial distribution of cumulative percent deforested area by the year 2012.

Deforestation in the Amazon is largely driven by two different dimensions of the region's industrial agricultural economy: the development of large-scale soya monocultures and of pastures for cattle ranching. In addition, in recent years, the exploitation of timber has also contributed substantially to deforestation in certain states, such as Mato Grosso (Soler, Verburg, and Alves, 2014). Since 2006, however, various federal initiatives, such as the creation of protected areas and of federal credit barriers, have worked to curb deforestation. However, even when controlling for these initiatives, we still see considerable variation in local deforestation.

As one of the most decentralized countries in the world, Brazil provides an ideal setting for

examining the role of local institutions. Brazilian municipalities have unparalleled autonomy in dictating local outcomes, and this autonomy applies to the management of deforestation. Interviews conducted with directors at the Ministry of Environment (*Ministério do Meio Ambiente-MMA*) and Municipal and State Secretariats of the Environment (*Secretaria Municipal do Verde e Meio Ambiente*) confirm that the 1988 Brazilian Constitution granted municipalities permission to act in relation to the environment. The mayor and the heads of municipal secretariats, in particular, have considerable discretion in the extent to which legislation on the limits to timber extraction and forest-clearing get enforced.

3 Local Political Competition and Deforestation

There is a growing literature in political economy that examines the politics behind environmental management. A major focus of this literature is on how regime type, especially democratic rule, affects environmental protection. On the one hand, a set of studies demonstrate that democratic regimes are positively associated with environmental protection (see, for example, Li and Reuveny (2006); Bernauer and Koubi (2009)). On the other hand, there is also ample evidence that democratic institutions have largely a negative correlation with various environmental indicators, including deforestation (Midlarsky, 1998; Sanford, 2021). Case study analyses of Kenya find that the introduction of multi-party elections in the country corresponded to annual loss of closed-canopy forest cover, and this trend was most pronounced in swing districts (Morjaria, 2012; Klopp, 2012). Related, recent work by Pailler (2018) finds evidence of electoral deforestation cycles, in which deforestation rates are higher in election years when incumbents run for re-election. This second set of studies align with authors who have made the observation that politicians facing competitive elections forsake protected forests in exchange for votes (Bates, 1979; Boone, 2003, 2014; Sanford, 2021).

Drawing on existing theories of electoral competition and qualitative evidence from semi-structured interviews conducted in Brazil, I build on this literature by exploring the exact ways in which local competitive elections in the Brazilian Amazon affect deforestation. Political competition increases the mayor's perceived risk of being voted out of office in the next election. Competitive elections, therefore, often create shortsighted politicians who strive to maximize their immediate

chances for re-election, competing with political opponents to exploit opportunities that provide short-term returns. As a result, mayors with such shortened time horizons are more prone to succumb to the demands of powerful vested interests (Meso-Lago, 1978; Grossman and Helpman, 1994; Huber, 1996; Weyland, 1996; Avelino, Brown, and Hunter, 2005). Across municipalities in the Brazilian Amazon, commercial agricultural interests often provide political candidates with various short-term returns using their financial leverage. They invest in political advertisements in favor of specific candidates or use their financial resources to control the local media directly. Consistent with existing theory, I argue that local political competition pressures mayors of the Brazilian Amazon to cater to such private commercial interests that profit from deforestation at the expense of long-term preservation goals.

Specifically, I argue that to achieve this end, mayors respond to competitive electoral environments by engaging in the strategic non-enforcement of environmental standards. As Brazil's former Minister of the Environment, Carlos Minc, noted in 2008, the mayoral post is the source of "ignoring illegal loggers." Holland (2017) illustrates her concept of forbearance, the intentional non-enforcement of laws, as a strategy for politicians to informally redistribute to the poor to win their votes. However, as she observes, politicians can also engage in a form of regressive forbearance that benefits those at the upper tranches of the income distribution. Holland (2017) finds that especially in poorer districts, mayors choose not to sanction illegal street vending to benefit the poor. In a similar vein, I expect that in municipalities with a greater presence of private commercial interests that deforest, mayors reduce the enforcement of environmental standards. In this first step of the the theoretical exposition, I argue that political competition encourages such forms of regressive forbearance (i.e., increases the rate of deforestation), and the presence of private commercial interests magnifies this effect.

Hypothesis 1 *Local political competition increases the rate of deforestation.*

Hypothesis 2 *The effect of political competition on deforestation is larger in municipalities with more private commercial establishments that deforest.*

A primary alternative theory is that the median voter herself may want deforestation if she prioritizes economic growth over environmental preservation. A critical question here is, who is

the median voter in the Brazilian Amazon? Does his preference ever align with that of private interests? In the empirical analysis, I first confirm that the median resident in municipalities in the Amazon is not employed in an industry, such as timber and soy, that profits from deforestation. In fact, in Amazonian municipalities, employment in such industries only comprises a negligible proportion –between 0.021% to 0.056%– of the population. In addition, using survey data from the Latin American Public Opinion Project (LAPOP), I demonstrate that the median respondent residing in a municipality in the Amazon has considerable valuation of environment preservation. Specifically, when asked to choose between environmental conservation and local economic growth, respondents prioritize the former (see Section 5.3 for more).[4]

I clarify that a key scope condition of the argument advanced in Hypothesis 1 is that environmental management is a low visibility issue area. I assume that political competition encourages politicians to focus on vested economic interests in place of the median voter under conditions of low political visibility. The median voter in the Amazon –even those employed in agriculture– is attuned to the need for sustainable rates of forest clearing. However, the protection of forest resources is a form of public welfare that exhibits low political visibility.[5] As an interviewed Coordinator of Environmental Planning in the State Department explained, "The problem with environmental preservation is that it's not a visible issue compared to other forms of welfare, such as education or health. People can't see and monitor it. We are invisible, in a castle... and because of this, the Environmental Secretariat is seen as a coin for exchanging political favors."[6] Common-pool resources exhibit distinctive features that give rise to a different set of political incentives than does the provision of public goods and services. The act of providing public goods –especially of infrastructural public goods– is one that is highly visible to the recipient constituency (Mani and Mukand, 2007). In contrast, localities are naturally endowed with "the commons." Relative to the political returns of provision, the *protection* of "the commons" exhibits a much lower level of

[4]The median resident living in the Amazon values environmental conservation much more than residents living in other regions of Brazil. These LAPOP survey questions are one of the only data sources for measuring public opinion towards the environment on a larger scale. Although "protecting the environment" is broad language, I assume that especially in municipalities in the Amazon, respondents' perceptions of "protecting the environment" center around deforestation, in particular.

[5]I define political visibility as both the degree to which a policy is tangibly (e.g., physically) observable by voters and the extent to which provision can signal a political commitment by a specific political party or candidate.

[6]Author interview with Teresa Castilho Mansor, *Coordenadoria de Planejamento Ambiental, Secretária de Estado do Meio Ambiente*, on June 29^{th}, 2016.

political visibility.

Because managing "the commons" exhibits low political visibility, the median voter is rarely in a position to hold politicians accountable. Instead, the onus for monitoring deforestation rests on municipal and state secretariats that issue environmental licenses and closely monitor adherence to these standards. I highlight that these local regulatory agencies play a critical role in that they are the main accountability mechanism that monitors deforestation. How can politicians pursue strategic non-enforcement in the presence of these monitoring agencies? Politicians cannot easily circumvent these institutions and procedures that have been in place since before their mandate. In addition, in such an ideological issue area, politicians also struggle to convince the long-standing "activist" bureaucrat to relax enforcement standards.[7] Therefore, to overcome these barriers, Brazilian mayors engage in a strategy I term "bureaucratic packing," the mass appointment of new personnel to bureaucratic agencies for the purpose of weakening enforcement. While electorally safe subnational executives tend to refrain from exercising this discretionary power, mayors facing electoral uncertainty have incentives to pack municipal secretariats. Such shifts in bureaucratic structure disrupts the institutionalization of the formal and informal procedures behind municipal regulatory politics. Because local secretariats are the primary accountability mechanism for such a low visibility issue area, the disruptive effects of "bureaucratic packing" are especially acute for monitoring deforestation.[8]

Interviews with local personnel working at the at the *Companhia Ambiental do Estado de São Paulo* (CETESB) and the *Secretaria Municipal de Meio Ambiente e Sustentabilidade* in Manaus and other municipalities reveal that the strategy of "bureaucratic packing" involves considerably increasing the number of personnel who are partial to the mayor's agenda, providing a supply of public servants who are amenable to regulatory forbearance.[9] Such occasions of bureaucratic expansion weakens regulatory capacity through two channels: 1) it dilutes the autonomy of each individual pre-existing personnel, and 2) it provides a supply of new personnel amenable to the mayor's

[7] The majority of interviewed local personnel have a strong personal stance towards environmental preservation and are often activists themselves.

[8] In high visibility issue areas, such as the building of health clinics, local health secretariats do not take on the same accountability role as do environmental secretariats.

[9] Author interview with various individuals at the *Companhia Ambiental do Estado de São Paulo* (CETESB) and *Secretaria Municipal de Meio Ambiente e Sustentabilidade* (Manaus and other municipalities) conducted in 2016 and in 2021.

agenda. Newly-appointed personnel can directly delay enforcement or force non-enforcement, even when long-serving public servants prove unwilling to aid these efforts. Critically, mayors with truncated time horizons recognize that there are legal and procedural difficulties with dismissing existing bureaucrats.[10] As a strategy, "bureaucratic packing," therefore, enables mayors to circumvent them by drawing on an alternative pool of newly-appointed personnel. Through bureaucratic expansion, the mayor, likewise, is in a better position to push through environmental licenses on commercial projects that would not have been approved as quickly or approved at all. As one interviewed public servant remarked, "We cannot deny the upsurge in environmental licensing around an election year... When the mayor faces a tough opposition, licenses get approved." [11]

"Bureaucratic packing" can affect appointments at different levels of seniority and expertise. As one interviewee explained, "All the secretaries of the environment, all the directors of the secretariats are appointed. It is a source of uncertainty that depends on the elections..."[12] When mayors face competitive elections and appoint new secretaries, the expectation is that these newly-appointed top-level professionals help facilitate the process of bureaucratic expansion. Top-level appointments, such as the appointments of the heads of the secretariats, can even change the agencies' overall stance towards environmental preservation. An interviewed public servant gave a particular example. "When we were working on a ruling for regulating land waste policy, our office received a call from the new secretary to drop the project... It was an article of the law that we had been working on for years, but we just crossed it off. His first day in office... one phone call, and we dropped the project. It was delayed for five years."[13] My interviewee went on to explain that the new secretary, overall, pursued a stance of regulatory forbearance. Her team increasingly struggled to withstand his efforts as the agency expanded in size.

Existing studies on patronage politics illustrate that politicians make civil service appointments for two purposes: either to reward political patrons or to exchange these positions for political services (e.g., campaigning, mobilizing voters) down the road (see, for example, Pierskalla and Sacks

[10] Empirically, I also confirm that political competition does not affect bureaucratic dismissals.
[11] Author interview with Ana Cristina Pasini da Costa at *Companhia Ambiental do Estado de São Paulo* (CETESB) on June 27^{th}, 2016.
[12] Author interview with Sra. Teresa Castilho Mansor, Coordenadoria de Planejamento Ambiental, Secretaria de Estado do Meio Ambiente, on June 29^{th}, 2016. Even in interviews with state-level bureaucrats, the focus of the interviews (of their responses) is always on municipal secretariats and procedures.
[13] Anonymous interviewee until permission received to reveal identity.

(2020); Brierley (2021); Oliveros (2021)). I argue that politicians also make mass appointments of new bureaucratic personnel with the purpose of weakening the ability of these local bureaucratic structures to function as a regulatory institution. In addition, the literature on bureaucratic capture emphasizes the ways in which private vested interests can corrupt existing bureaucrats to achieve economic ends. Alternatively, even when existing personnel cannot be corrupted, they can be circumvented through a process of bureaucratic expansion. In municipalities across the Brazilian Amazon, subnational executives concerned with winning the margins are pressured to pursue regulatory forbearance of less visible policy areas, such as of the enforcement of environmental standards, as a means to cater to vested interests. Competitive elections, in turn, encourage "bureaucratic packing" as a strategy to undermine regulatory capacity. The hypotheses are, therefore, as follows.

Hypothesis 3 *Local political competition increases the appointment of new personnel in municipal secretariats.*

Hypothesis 4 *Such surges in new personnel are negatively associated with deforestation.*

4 Data and Research Design

The main explanatory variable is political competition in municipal elections for mayor, a concept I measure in three different ways (see Appendix). The main measure I use is that of the mayoral margin of victory (i.e., difference in vote shares between the winning and runner-up candidate) in the previous election, following standard practice in the literature on political competition in comparative politics.[14] When margin of victory in the previous election is a strong predictor of the incumbent's performance in the current election, it can be used as a measure of the expected electoral competitiveness of the election in the current period. To test this assumption, I use a logit estimation framework with simulated effects to determine whether the previous electoral cycle's margin of victory for the winning candidate predicts an incumbent win in the current electoral cycle. The estimation shows that the odds of winning the current election increases by 9.0% for every 10 percentage point boost in margin of victory in the previous election. The

[14]The data is from Brazil's Electoral Court. (See http://www.tse.jus.br/.

distribution of the measure for the 2000, 2004, and 2008 elections is shown in Figures A4 in the Appendix. As the figures show, the level of political competition exhibits considerable variation across Amazonian municipalities and also over time.

The primary dependent variable is the logarithmized value of the deforested area in square kilometers in municipality i at time t. Given that the variable is logarithmized, changes in the forest cover are estimated as a percentage of the total, allowing us to account for variation in both municipality size and initial forest cover.[15] To assess bias in the estimates from non-random assignment of margins of victory, I regress rainfall and cloud coverage on the margin of victory. The results, shown in Table A15 in the Appendix, make clear that there is no statistically significant partial correlation between the margin of victory and rainfall or cloud coverage. This observation suggests that the margin of victory is not spatially correlated with the conditions for rainforest growth or depletion.

Next, I test the main hypotheses using a panel regression design to estimate the association between the mayor's margin of victory in the previous election and deforestation during the mayor's four years of rule for electoral mandates throughout the 2000-2012 period. The list of 783 municipalities in the Legal Amazon is based on the 2000 census of Brazil, giving a total of 10,179 municipality-year observations of deforestation[16]

The main model is specified as follows:

$$Y_{m,t} = \alpha_m + \beta_1 \text{MoV}_{m,t} + \sum_k \gamma_k x^k_{m,t} + \mu + \epsilon_m, \tag{1}$$

where m denotes municipalities and t years. The variable MoV is the ruling mayor's margin of victory in the previous election. Variables x^k are control variables and μ is a vector of state-year fixed effects. I cluster robust standard errors by municipality. The main assumption of this research design is that through the inclusion of various fixed-effects and control variables I can deal with omitted variable bias. Below, I provide evidence for this identification assumption by

[15] I do not, however, include a time-varying control for forest cover, because such a control would induce Nickell (1981) bias in the presence of fixed effects.

[16] The number of observations in the estimations, at times, varies as a result of missing data for certain controls variables.

running various placebo tests. I include municipality fixed-effects throughout to ensure that the estimation is only based on within-municipality variation. The fixed-effects control factors that are time-invariant (e.g., land area) or slow-moving (e.g., institutional capacity to deal with illegal deforestation). All models also include state-year fixed effects to account for secular trends in the nine states that constitute the Legal Amazon, such as state policies and variation in commodity prices.

To adjust for Brazil's federal deforestation program, I also include indicators for the assignment of priority status – in other words, blacklisting – to municipalities during the enhanced efforts to control deforestation that the federal government initiated in 2008. The priority status is coded '1' in the year of enactment and until the municipality is no longer considered a priority, if ever. Another adjustment for national forest conservation programs is a control variable for the share of municipal area designated as Protected Areas (0-1), under Brazilian Law 9,985 in July 2000. See Appendix A1 for more information. I also test the robustness of the results to the inclusion of a wide array of control variables, such as incumbent electoral victory, number of cattle, soybean cultivation (hectares), rainfall (annual, in decimeters), and cloud coverage. In Appendix A1, I discuss in greater detail why these variables are relevant and the exact data sources used to measure them. The summary statistics for all variables are shown in Tables A1-A2 and the histograms in Section A3 in the appendix.

4.1 A Shift-Share Instrument for Estimating Political Competition

A possible concern with the empirical strategy is the endogeneity of local electoral competition to deforestation. The theory maintains that local electoral competition increases deforestation, but deforestation could also shape the extent of local electoral competition by changing vote choices. To check this possibility, in Table 1, I estimate the association between the mayor's margin victory and the four-year lag of deforestation. Given municipal elections in Brazil occur every four years, the placebo test checks for the possibility that historical trends in deforestation is what is driving the results on current period deforestation. As Table 1 below shows, the mayor's margin of victory does not predict past deforestation, supporting the identification assumption behind the panel fixed-effects regression design. Political competition may induce deforestation, but not vice versa.

Table 1: Placebo Test for Reverse Causality in Panel Fixed-Effects Estimations

	Dependent variable:				
	Deforestation (log, four-year lag)				
	(1)	(2)	(3)	(4)	(5)
Mayor Margin of Victory (0-1)	−0.005	−0.003	−0.002	−0.011	0.030
	(0.045)	(0.045)	(0.045)	(0.043)	(0.056)
Incumbent Win		−0.001	−0.001	−0.008	−0.007
		(0.014)	(0.014)	(0.013)	(0.021)
Cloud Coverage (log)			0.0004	0.0003	0.005
			(0.003)	(0.003)	(0.003)
Mean Rainfall (dms per pentad)			−0.008***	−0.009***	−0.006*
			(0.003)	(0.003)	(0.004)
Number of Mayoral Candidates				0.0002	0.008
				(0.008)	(0.011)
Workers' Party (PT)				−0.038*	−0.065**
				(0.021)	(0.028)
Existence of Environmental Councils				−0.011	−0.025
				(0.013)	(0.017)
Priority Municipality				0.159***	0.151***
				(0.025)	(0.033)
Protected Areas (0 - 1)				0.098	0.090
				(0.126)	(0.142)
Cattle (log)				0.075***	0.053**
				(0.023)	(0.026)
Soybeans (log)					0.003
					(0.009)
Municipality Fixed Effects	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓
Observations	6,854	6,849	6,849	6,779	4,295

Note: *p<0.1; **p<0.05; ***p<0.01

Table 1: This table shows the results from placebo tests that confirm that mayoral margin of victory present day has no effect on deforestation four years ago.

To further address the causality of the effect, I follow Shaukat (2019) in constructing a shift-share instrumental variable (SSIV) that exploits changes in the popularity of each political party in elections for state-level office to predict political competition in municipal elections. Although critics of instrumental variable designs have cast doubt on the validity of the estimation strategy in general, recent developments in SSIVs prove to be an exception. In her dissertation, Shaukat (2019) develops a SSIV to examine subnational competition in India. I, instead, adapt it to the Brazilian context. The instrument takes advantage of the fact that a party's performance at higher levels of government can also have an impact on how it fares in local elections. To give a concrete example, the 2014 federal-level corruption scandal, known as *Lava Jato* ("Operation Car Wash"), that implicated Brazil's popular Worker's Party (*Partido dos Trabalhadores*-PT) also had consequences for local candidates affiliated with the PT. Municipal elections in Brazil are staggered from state-level elections by 2 years. Therefore, I use, for example, the change in party support between the 1998 and 2002 state-level elections for governor and for state deputies affiliated with the party to predict the change in vote share for the party between the 2000 and 2004 municipal elections. Because I examine changes in municipal political competition that are driven exclusively by actions at the state- or federal-levels, they are not endogenous to other municipal-level characteristics.

Although municipal partisan affiliation is weak in Brazil, empirically, this concern is moot as long as the first-stage test of the instrumental variable indicates a strong first-stage effect. The construction of the instrument leverages changes in party support among only the largest (i.e., strongest) parties that have a consistent subnational presence over time in Brazil. The instrument's design, therefore, filters out short-lived parties and, in some cases when relevant, also accounts for municipal coalition (*coligações*) structures in its construction. Despite how municipal partisan identities can be weak in Brazil, several major parties, such as the PT, PSDB, PMDB, PFL, among others, exhibit strong partisan identities at both the state- and municipal-levels. Thus, empirically, state-level partisanship still strongly predicts the success of municipal co-partisans, as indicated by the strong first-stage effect of the instrumental variable (see Table 4).

In contrast to a standard shift-share instrument, the "shifts" (i.e., changes in aggregate party popularity) in this case affect political competition across each municipality non-monotonically (Shaukat, 2019). In other words, a positive shift in a specific party's performance at higher levels

of government *decreases* political competition in municipalities where the party holds a majority, yet it *increases* competition in municipalities where the opposition has a stronghold. Non-monotonicity is, therefore, a key identification assumption. In Appendix A5, I thoroughly discuss the identification assumptions behind this shift-share approach in greater detail. Following Shaukat (2019), I construct the following measure of predicted vote shares, $\hat{s}_{p,m,s}$ for each party p in municipality m and state s at time t (i.e., the 2004, 2008, and 2012 municipal elections):

$$\hat{s}_{p,m,s,t} = z_{p,m,s} + g^{-m}_{p,s,t} \tag{2}$$

$z_{p,m,s}$ represents the party vote share in the baseline election year –in this case, the 1998 state elections. $g^{-m}_{p,m,t}$ is a measure of the aggregate change in party vote share at the state-level that leaves out only that change in support for that party in municipality m. This leave-out feature in the calculation of the shifts ensures that they are not driven by location-specific factors, such as the behavior of the incumbent in municipality m (Shaukat, 2019). Next, I plug in the predicted vote shares calculated for each municipality-year's winning mayoral party w, $\hat{s}_{w,m,s,t}$, as well as that for the strongest runner-up opposition party o, $\hat{s}_{o,m,s,t}$, into the calculation of political competition as follows:

$$\text{Pred. Competition}_{m,s,t} = 1 - \mid \hat{s}_{w,m,s,t} - \hat{s}_{o,m,s,t} \mid \tag{3}$$

And I use this measure of predicted competition to instrument for the actual competition between the incumbent and opposition parties in each municipal election. In other words, I use the following empirical framework:

First-Stage:

$$\text{Competition}_{m,s,t} = \mu + \delta \text{ Pred. Competition}_{m,s,t} + \gamma_m + \omega_{s,t} + \epsilon_{m,s,t} \tag{4}$$

Second-Stage:

$$\bar{y}_{m,s,t} = \alpha + \beta \text{ Competition}_{m,s,t} + \gamma_m + \omega_{s,t} + \varepsilon_{m,s,t} \tag{5}$$

where Pred. Competition$_{m,s,t}$ is the predicted competition instrument calculated in Equation (3), γ_m indicates municipality fixed-effects, and $\omega_{s,t}$ is state-year fixed-effects. I estimate two-staged least squares (2SLS) both with and without municipal-level controls to observe the robustness of the results to potential bias from conditioning on concomitant variables. In the Appendix A8, I show balance on these municipal-level variables for the instrument.

5 Empirical Findings

5.1 Main Results

The main results using panel fixed-effects estimation (Equation 1) are shown in Table 2.

Table 2: Main Results using Panel Fixed-Effects

	Dependent variable:				
	Deforestation (log)				
	(1)	(2)	(3)	(4)	(5)
Mayor Margin of Victory (0-1)	−0.067**	−0.067**	−0.063**	−0.069**	−0.090**
	(0.027)	(0.027)	(0.027)	(0.027)	(0.042)
Incumbent Win		0.007	0.006	0.002	0.010
		(0.004)	(0.004)	(0.005)	(0.006)
Cloud Coverage (log)			0.016***	0.014***	0.016***
			(0.002)	(0.002)	(0.003)
Mean Rainfall (dms per pentad)			−0.010***	−0.011***	−0.012***
			(0.002)	(0.002)	(0.003)
Number of Mayoral Candidates				−0.004	−0.003
				(0.005)	(0.007)
Workers' Party (PT)				−0.016	−0.017
				(0.010)	(0.012)
Existence of Environmental Councils				0.004	0.014
				(0.008)	(0.011)
Priority Municipality				0.128***	0.116***
				(0.016)	(0.019)
Protected Areas (0 - 1)				0.188***	0.159**
				(0.069)	(0.074)
Cattle (log)				0.024*	0.023
				(0.013)	(0.016)
Soybeans (log)					−0.005
					(0.006)
Municipality Fixed Effects	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓
Observations	9,799	9,788	9,788	9,706	6,698

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2: This table shows the main results. The dependent variable is the logarithmized value of the deforested area within a municipality. The model is linear and standard errors are clustered by municipality across all models.

The association between a high margin of victory – a measure of low political competition – and low deforestation is robust. Across the models, the coefficient for margin of victory is negative, statistically significant, and shows little sensitivity to specification. In other words, political competition (low margin of victory) increases deforestation. In the most comprehensive model (5), increasing the margin of victory by 10 percentage points decreases deforested area by one percentage point. A standard deviation's increase in the margin of victory, on the other hand, decreases deforested area by 1.3 percent. With a mean deforested area of about 20 percentage points in 2012, this is a relatively large decrease. These results are consistent with the hypothesis that political competition directly affects the depletion of natural resources.

Specifically, the theory (i.e., Hypothesis 2) maintains that the presence of private commercial interests that deforest accounts for this effect. Political competition encourages mayors concerned with winning the margins to cater to private interests in agriculture. To test Hypothesis 2, I use data from the Brazilian Agricultural Census available for the year 2006, that measures the number of commercial agricultural establishments by municipality. The measure excludes establishments owned by small-holder farmers to capture exclusively large-scale commercial agricultural establishments. In municipalities in the Amazon, the measure is, therefore, a good proxy for the presence of commercial agricultural interests that deforest. I, once again, estimate the association between political competition and deforestation using fixed-effects estimation, though, I include the interaction of political competition and this measure of private interests in the estimation. In Table 3 below, Model (1) presents the regression of deforestation on the number of commercial agricultural establishments, and Models (2) through (4) demonstrate the robustness of this result to the inclusion of the control variables. In addition, Model (5) presents the results from the estimation with the interaction term, and Model (6) shows the results from the same estimation with, however, the control variables.

Table 3: The Effect of Commercial Agricultural Interests

	Deforestation (log)					
	(1)	(2)	(3)	(4)	(5)	(6)
Agricultural Establishments (Hundreds)	0.250***	0.247***	0.260***	0.225***	0.327***	0.292***
	(0.080)	(0.080)	(0.085)	(0.078)	(0.068)	(0.068)
Mayor Margin of Victory (0 - 1)					0.484	0.253
					(0.460)	(0.466)
MoV × Agricultural Establishments					-0.542***	-0.446**
					(0.185)	(0.180)
Incumbent Win		0.068	0.067	0.033		0.032
		(0.076)	(0.074)	(0.074)		(0.076)
Cloud Coverage (log)			0.101***	0.117***		0.115***
			(0.025)	(0.027)		(0.027)
Mean Rainfall			0.091***	0.093***		0.095***
			(0.019)	(0.018)		(0.018)
Number of Mayoral Candidates				0.006		-0.012
				(0.046)		(0.047)
Workers' Party (PT)'				-0.042		-0.081
				(0.183)		(0.185)
Existence of Environmental Councils				0.348***		0.325***
				(0.117)		(0.115)
Priority Municipality				1.594***		1.504***
				(0.181)		(0.175)
Protected Areas (0 - 1)				-0.449*		-0.441*
				(0.231)		(0.232)
Observations	10117	10004	10004	9872	9773	9691

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The results show that as expected, the number of commercial agricultural units corresponds negatively with deforestation. Consistent with the main results, an increase in margin of victory (i.e., a decrease in political competition) has a strong negative association with deforestation. Last and critically, this effect of margin of victory is reduced as the number of commercial agricultural establishments increases. As predicted, the effect of political competition on deforestation is conditional on the presence of private commercial interests, providing direct evidence in support of Hypothesis 2.

5.2 2SLS Estimation with the Shift-Share Instrument

As discussed in the section that details methodology, to further ascertain the causality of the effect, I estimate 2SLS models using the constructed shift-share instrumental variable for political competition. In Table 4 below, Model (1) presents the first-stage effect of the instrument, while Model (2) shows the corresponding second-stage estimate for deforestation (logged). The Kleibergen-Paap rk Walk F-statistic is 13.243. The Cragg-Donald Wald F-statistic is 78.198, which is above the Stock-Yogo critical value for 10% size (16.38), 15% size (8.96), 20% size (6.66), and 25% size (5.53). These F-Statistics, therefore, does not leave concern of a weak instrument. The instrument has a strong first-stage. As discussed earlier, I calculate a measure of the competitiveness of elections directly (Equation 3). Thus, while the main panel fixed-effects models use the measure of margin of victory (i.e., less competition), the estimates here should be interpreted as the effect of, instead, an *increase* in political competition. The estimates are comparable to those reported in Table 2. A 10 percentage point increase in political competition increases deforested area by around 1.1 percent.

Table 4: 2SLS Estimation using SSIV

	(1) First-Stage	(2) Deforestation (logged)
Predicted Competition (0 - 1)	0.070***	
	(0.019)	
Actual Competition (0 - 1)		0.116**
		(0.054)
Municipality Fixed-Effects	✓	✓
State-Year Fixed-Effects	✓	✓
Observations	7,820	7,820
F-Stat	13.24	

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

This table presents results from the 2SLS estimations using the political competition shift-share instrument. The estimations exclude municipal-level controls to avoid bias if I condition on concomitant variables.
I instead show balance on these variables in the Appendix.

5.3 Who is the Median Voter in the Amazon?

As discussed in the section on the theory, it is relevant to clarify the identity of the median voter and his preference. If the median voter prefers deforestation, then it could just be the case that increased political competition makes politicians more responsive to local demands for forest clearing. I first clarify the occupational identity of the median resident in the Brazilian Amazon using detailed Brazilian census data available from the *Instituto Brasileiro de Geografia e Estatistica* (IBGE) on the spatial local of residents and their choice of labor.

The results in Table A3 in the Appendix first presents the mean, minimum, and maximum share of residents involved in the soy, timber, or cattle industries for municipalities in the Amazon. As the results show, on average, only 0.029% of each municipality is involved in the production of soy, only 0.021% in timber, and 0.056% in cattle. The maximum municipal share of soy, timber, and cattle producers are 4.292%, 2.352%, and 1.677%, respectively. Therefore, the median resident in the Amazon is not linked to an industry that profits from deforestation. For good measure, Table A3 also reports that the mean share of households involved in any type of agricultural activity is only 13.44%, and the maximum share is 39.551%. The median resident, therefore, is also not employed in the agricultural sector at all.

Next, I use different waves of public opinion survey data from the Latin America Public Opinion Project (LAPOP) to examine preferences for environmental conservation among respondents that reside specifically in municipalities in the Amazon region of Brazil. First, the 2014 wave of LAPOP has a question that asks respondents, "In your opinion, what should be given priority: protecting the environment or promoting economic growth?" The question is coded as an indicator variable with 1 capturing prioritizing the environment over growth. As the descriptive statistics in Table A4 in the Appendix show, around 80% of respondents in the Amazon prioritize the environment over economic growth. This can be compared to the 72% respondents who prioritize the environment in the Brazil sample at large (i.e., all of Brazil excluding respondents from the Amazon). This analysis make clear that environmental conservation is a salient issue area that is on par with –or rather, even more highly valued than– local economic development. Next, the 2017 wave of LAPOP has a question that asks respondents, "If nothing is done to reduce climate change in the future, how

serious do you think the problem would be for Brazil?" Responses range on a scale from 1 to 4, where 4 captures "Very (Most) Serious." As Table A4 shows, the median response in both the Amazon sample and the sample with the rest of Brazil is 4. The mean response in both samples is comparable: around 3.6, although the larger Brazil sample is slightly higher. It is clear that Brazil is a very environmentally conscious country overall. However, there is even more support for protecting the environment among respondents in the Amazon.

Although "protecting the environment" and "climate change" are broader concepts, I assume that especially in municipalities in the Amazon, the cognitive comparison of the environment to economic growth centers around deforestation, in particular. These strategies for understanding the median voter are far from ideal. Nonetheless, they are the only available approaches, given the dearth of data on preferences regarding the environment. In interviews with locals and observations from attending neighborhood association meetings, I have also observed that preservation of the Amazon is politically salient for voters in the region. However, the LAPOP survey questions offer the only option for observing this trend on a larger scale.

5.4 "Bureaucratic Packing"

In this section, I further examine how political competition alters the political behavior of Brazilian mayors. The qualitative evidence presented points to the ways in which political competition incentivizes mayors of Brazil to engage in "bureaucratic packing," a surge in new appointments in municipal secretariats that undermines regulatory capacity. To test Hypothesis 3 further on a larger scale, I use data from the *Relação Anual de Informações Sociais* (RAIS) available from Brazil's Ministry of Labor and Employment. The RAIS data is annual survey that documents the complete universe of all labor contracts for public employees. The database notes the the start and end dates of all contracts, the legal nature or category of profession of the contract, and various other characteristics. Using the RAIS database, I calculate measures of "bureaucratic packing" to use as an independent variable. Specifically, the main measure I use is the count of municipal personnel (logarithimized) who were newly appointed within 12 months after each municipal election between 2000-2012 to capture the immediate reactionary effects to each election.

As with the main results presented in Table 2, I estimate panel fixed-effects models of new

municipal personnel on mayoral margin of victory. The models include municipality and state-year fixed-effects and robust standard errors clustered by municipality. The results, presented in Table 5 below, confirm a strong and robust negative association between mayoral margin of victory –i.e., low political competition– and new personnel within municipal bureaucracies.

Table 5: Political Competition and Municipal Bureaucratic Appointments

	Dependent variable:				
	New Municipal Personnel (log)				
	(1)	(2)	(3)	(4)	(5)
Mayor Margin of Victory (0 - 1)	-0.379*	-0.400**	-0.383*	-0.339*	-0.710**
	(0.196)	(0.198)	(0.196)	(0.199)	(0.327)
Incumbent Win		0.038	0.031	0.023	0.128
		(0.054)	(0.054)	(0.055)	(0.093)
Cloud Coverage (log)			0.068**	0.063**	0.065
			(0.027)	(0.027)	(0.044)
Mean Rainfall			0.015	0.020	0.003
			(0.018)	(0.018)	(0.032)
Number of Mayoral Candidates				-0.011	-0.025
				(0.033)	(0.049)
Workers' Party (PT)'				0.157	0.109
				(0.108)	(0.195)
Existence of Environmental Councils				-0.031	-0.055
				(0.068)	(0.110)
Priority Municipality				-0.060	0.000
				(0.143)	(.)
Protected Areas (0 - 1)				0.975*	1.477**
				(0.534)	(0.632)
Cattle (log)				-0.049	-0.043
				(0.105)	(0.154)
Soybeans (log)					0.019
					(0.056)
Municipality Fixed Effects	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓
Observations	2,577	2,573	2,573	2,549	1,358

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Margin of victory and municipal bureaucratic appointments: panel fixed-effects models with standard errors clustered by municipality.

Specifically, in the most comprehensive model (Model 5), a 10 percentage point increase in margin of victory corresponds to a decrease in new municipal personnel by around 7 percentage points. The reverse is also true: a decrease in MoV (i.e., an increase in political competition) increases the appointment of municipal personnel. In addition, in Appendix A7, I run panel fixed-effects estimation of deforestation on the appointment of new municipal personnel, and the results confirm, instead, a strong positive association. "Bureaucratic packing," in turn, corresponds to an increase in deforestation. This set of results provides direct support for the theory that competitive elections encourage the mayor to pursue a strategy of bureaucratic expansion to enable deforestation (Hypotheses 3 and 4). Consistent with the claim that politicians engage in "packing" especially when removing existing personnel proves difficult, I find that competitive elections are not associated with an increase in bureaucratic *dismissals*, indicating bureaucratic *turnover* is not the mechanism.

5.5 Checks for Robustness

In Section A6 in the Appendix, I also explore a series of tests of the robustness of the results. First, in Table A11, I find that even when margin of victory is allowed to have nonlinear effects, low margin of victory consistently has positive coefficient estimates, suggesting that political competition indeed contributes to deforestation. Next, in Table A12 in the Appendix, I examine how the results change if I exclude geographic areas (observations) that have very little remaining forested area. The table shows that the results are robust when progressively excluding municipalities with minimal forest cover. The results are not sensitive to using differential cut-offs for low-forest coverage municipalities. This robustness test shows that the logarithmized approach is valid and does not bias the results.

In Table A13 in the Appendix, I next show the results when states in the Amazonia Legal are dropped one-by-one. This jackknife estimation can be used to check that the results are not driven by any particular state. I also test for the robustness of the results when I exclude margins of victory in excess of 70 percentage points. The results are shown in Table A14 in the Appendix. This cutoff was chosen, because investigation of the data shows that some municipalities in the 70-80 percentage point range for MoV may be outliers in their conservation efforts. The results

remain robust for both of these tests.

5.6 Testing Alternative Explanations

I first consider the role of market forces as an alternative channel. As I have noted earlier, deforestation largely stems from the agro-industrial economy. Therefore, local political competition could have an unintended effect on deforestation through increased or decreased economic activity. To be clear, this alternative channel of local economic activity (e.g., cattle ranchers, farmers, etc.) is different from vested private sector interests who extract profits from the region and lack a stake in generating growth in the local economy. In a similar vein, the political incentives to focus on economic growth differ from those that encourage a focus on vested private interests. To account for these agro-economic drivers of deforestation, I conduct placebo tests to discern the plausibility of this alternative channel in Tables A16 and A17 in the Appendix.

Table A16 examines whether the main agro-industrial drivers of deforestation could confound the observed effects of political competition on the destruction of the commons. In Model (1), margin of victory actually increases the number of cattle in the municipality: a 10-percentage point increase in the margin of victory increases the number of cattle by more than one percent. This indicates that cattle ranching does not explain why high political competition (i.e., low margin of victory) increases deforestation.[17] Model (2), in turn, shows that there is no effect of margin of victory on area for soybean cultivation. Taken together, the results from both tables illustrate that local economic activity does not drive the results.

Another alternative explanation that could confound the observed effects of municipal activity on deforestation is the implementation of federal policy. Specifically, I examine whether the effects are driven by the Brazilian Institute of Environment and Renewable Natural Resources's (IBAMA) federal program of embargoes. One of the main federal initiatives to counteract deforestation, the program allows the federal government to impose an embargo on municipalities that exceed set deforestation rates. I also conduct a related test where I regresses the share of municipal area designated by the federal government as a Protected Area (PA) on the mayor's margin of victory.

[17] Mayors with high margins of victory do not reduce cattle ranching or soybean cultivation. If anything, livestock raising appears to increase.

As Models (3) and (4) in Table A16 in the Appendix show, Brazil's main federal policy initiatives for preservation, such as the IBAMA embargo program or the designation of Protected Areas (PA), do not drive the results.

Next, I also consider the role of poverty and land inequality. Given that municipalities in Amazon depend on resource extraction, it could be that we only see the largest effects of political competition in poor areas. I include municipality fixed effects to control for income effects, but I also estimate an interaction model that tests poverty (i.e., municipal income) as a modifying factor. In addition, I investigate whether land inequality conditions the effects of political competition to see if the incentives outlined above depend on the concentration of natural resources in the hands of a small number of large landowners. The results, provided in Table A18 in the Appendix, indicate that poverty and land inequality are not alternative mechanisms that explain the results.

I also estimate models that allow the effect of margin of victory to depend on the mayor's partisanship (partisan politics hypothesis), the state governor's partisanship (state policy execution), monthly income per capita (based on the 2000 census, in constant Reais, year 2000 prices), and a Gini coefficient for land inequality (based on the 1995 agricultural census). The income and land inequality measures are cross-sectional, so I do not include the constituent term in the regressions, as it would be subsumed by the municipal fixed-effects. For data on land inequality, see Albertus, Brambor, and Ceneviva (2016). As the Table A19 in the Appendix shows, there is very little evidence for interactive effects. Once I control for whether the mayor is a first- or second-term office-holder, the interaction coefficient becomes small and statistically insignificant. Taken together, these findings lend little evidence for arguments that emphasize the special role of partisanship and of Lula's PT, in particular, in the municipal politics of deforestation. Likewise, Table A20 in the Appendix shows an alternative theory that emphasizes the role of state-level intervention on the part of the governor in monitoring local deforestation also would not be consistent with the results.

6 Conclusion

Deforestation is a major contributor to climate change, a threat to indigenous rights and livelihoods, and a source of considerable biodiversity loss. Much of the literature on the causes of deforestation focus on the market mechanisms that drive such environmental degradation. However, the underlying political institutions that shape the destruction of the commons have received much more limited attention. I use a combination of panel fixed-effects estimation and a novel shift-share instrumental variable approach proposed by Shaukat (2019) to systematically explore the effects of political competition, in particular. Using detailed satellite imagery data on forest coverage over time, the analysis finds that local political competition has a robust causal and positive effect on deforestation. Contrary to standard models of political accountability that touts the benefits of democracy for the provision of public goods, the results demonstrate that competitive elections undermine the management of the the commons.

Unlike with the provision of public goods, the protection of the commons exhibits a much lower level of political visibility, rendering the median voter often incapable of holding politicians accountable. Thus, the management of the commons in Brazil relies heavily on local environmental secretariats, instead, as the primary accountability mechanism that checks the deforestation of the Amazon. Drawing on qualitative evidence from interviews with public servants, I argue that competitive elections encourage a focus on private vested interests that deforest. To pursue this end, mayors in Brazil engage in a strategy of bureaucratic expansion to pursue the strategic non-enforcement of environmental standards, a form of regressive forbearance. Leveraging a detailed database of public employment contracts, I find that local political competition, indeed, corresponds to an increase in the appointment of new municipal personnel within only the first 12 months after each competitive election.

The analysis spotlights "bureaucratic packing" as an understudied strategy, illustrating the ways in which political competition generates incentives for weakening bureaucratic capacity on the part of the mayor. The results also provide a piece of robust evidence for the political origins of deforestation, addressing the methodological and measurement difficulties that comes with studying political competition by leveraging a novel quasi-experimental strategy for causally es-

timating its effects. Beyond illustrating the role of private commercial interests and the strategy of "bureaucratic packing," the analysis carefully considers a set of prominent alternative mechanisms, such as partisan alignment across levels of government, federal policy mechanisms that seek to curb illegal deforestation, land inequality and local development, among others, showing these alternatives cannot explain the observed effect of political competition. The results spotlight the need for developing new theory and systematic evidence for understanding the effects of democratic institutions on the environment and on bureaucratic capacity.

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The Political Origins of Deforestation in the Brazilian Amazon, 2000-2012

Online Appendix

October 13, 2022

Contents

A1 Research Ethics and Transparency

I confirm that the human subjects research pursued complies with the standard principles and and regulation for human subjects research and was approved the appropriate research ethics committee. This paper draws on qualitative data collected from engaging directly with human participants. For this part of the analysis, participants were recruited via email or phone outreach, and preliminary consent was solicited during recruitment before meeting in person. A few participants were recruited in-person after an encounter at, for example, a neighborhood association or other civic association meeting. Participants were read a consent agreement that provides complete information regarding the objectives of the research, and oral consent was solicited. Participants were read the terms of consent in their native language (i.e., Portuguese), and the researcher ensured they fully understood all the terms, benefits, and risks of participating in the interview. The oral script detailing consent includes 1) a description of the interview procedures, 2) a statement detailing the the activities involved in the research, 3) a statement that participation is voluntary, and d) the primary investigators name and contact information.

No deception of any kind was used, and the nature of the research and qualitative data collected is not sensitive, posing minimal risk to participants. The interview questions for bureaucrats were focused on understanding internal bureaucratic procedures in regards to environmental licensing and impact statements. Given those interviewed were inherently outspoken regarding environmental issues and political misdemeanors, the interview questions did not solicit information that is more sensitive than the conventional public statements made by participants. For these reasons, the data collection procedures have been approved by an Institutional Review Board under specifically expedited review and with exempt status. No compensation was paid to the human participants, but rather the subjects interviewed were volunteers.

In regard to confidentiality, during the process of soliciting informed consent, participants were informed that they may be quoted directly from their interview, and that the qualitative information gathered is identifiable, but were given the option to conduct the interview anonymously if preferred. Most participants chose to be identified. The identities of interviewed participants are, therefore, disclosed in the manuscript. Again, because the interview questions did not solicit sensitive information nor could they pose physical, reputational, or employability risks to participants, the IRB review allowed interview data collection that is identifiable. If accepted for publication, the author may ask quoted participants for additional permission to publish their quotes and may ask the journal for permission to anonymize certain quotes if requested.

A2 Data Description: Summary Statistics

I first estimate a wide range of panel models with and without different sets of control variables. First, I include an indicator for the previous incumbent's electoral victory, calculated based on electoral records from the *Tribunal Superior Eleitoral* (TSE). Next, some models include control variables for cattle farming and the area of soybean cultivation in hectares, both logarithmized. The data is available from the agricultural database of the IBGE and from Brazil's Ministry of Agriculture, respectively. These economic fundamentals affect deforestation, and by including them in some but not all models, I can see if political competition affects deforestation through changes in these related economic activities or through some other channels. Some of the models also include controls for rainfall (annual, in decimeters) and cloud coverage (percentage), because cloud coverage prevents satellites from detecting deforestation. I use the Terrestrial Precipitation: 1900 - 2010 Gridded Monthly Time Series data set provided by Kenji Matsuura and Cort J. Willmott of the University of Delaware. Tables A1-A2 provide additional descriptive statistics of all these variables:

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Municipality Mean Descriptive Statistics													
Mean Deforestation	682.13	751.93	785.61	824.33	859.13	889.72	903.64	918.33	935.36	942.83	951.89	958.30	965.89
Mean Forest Coverage	4443.13	4375.54	4345.48	4309.24	4267.60	4201.37	3982.06	3838.64	3922.22	3877.41	3604.79	3772.86	3758.84
Mean Margin of Victory (0 - 1)	0.14	0.16	0.16	0.16	0.16	0.14	0.14	0.14	0.14	0.16	0.16	0.16	0.16
Mean Number of Mayoral Candidates	3.20	2.87	2.87	2.87	2.87	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.89
Mean Cattle (log)	10.06	10.08	10.17	10.26	10.37	10.43	10.44	10.38	10.41	10.43	10.46	10.48	10.48
Mean Soybeans (log)	4.98	4.96	4.91	5.00	5.05	5.14	5.13	5.14	5.10	5.15	5.15		
Mean of Mean Rainfall (dms per pentad)	20.01	19.06	17.91	18.58	19.32	18.66	19.74	17.87	20.66	21.24	17.30	20.29	17.22
Mean of Protected Areas (0 - 1)	0.17	0.18	0.19	0.19	0.19	0.20	0.21	0.21	0.22	0.22	0.23	0.23	0.23
Municipality Count Descriptive Statistics													
Total Number of PT Mayors	15.00	25.00	25.00	25.00	25.00	73.00	73.00	73.00	73.00	91.00	91.00	91.00	91.00
Total Number with Environmental Councils	100.00	138.00	138.00	138.00	202.00	202.00	202.00	202.00	267.00	334.00	334.00	334.00	404.00
Total Number of Incumbent Wins	0.00	271.00	271.00	271.00	271.00	181.00	181.00	181.00	181.00	255.00	255.00	255.00	255.00
Total Number of Priority Municipalities	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.00	41.00	40.00	43.00

Table A1: This table shows the municipality mean and municipality count descriptive statistics by year for the sample of municipalities with deforestation in Brazil, 2000-2012.

	Average	Standard Deviation	Minimum	Maximum
Deforestation (log)	5.25	2.58	0.00	9.76
Margin of Victory (0 - 1)	0.15	0.14	0.00	0.99
Incumbent Win	0.28	0.45	0.00	1.00
Number of Candidates	2.91	1.10	1.00	10.00
Workers Party (PT)	0.08	0.27	0.00	1.00
Environmental Councils	0.30	0.46	0.00	1.00
Priority Municipality	0.02	0.12	0.00	1.00
Protected Areas (0 - 1)	0.20	0.32	0.00	1.00
Cattle (log)	10.34	1.73	0.00	14.58
Soybeans (log)	5.06	1.49	0.00	10.35
Cloud Coverage	1.10	2.18	0.00	10.89
Mean Rainfall (dms per pentad)	19.07	4.76	0.08	43.07

Table A2: This table shows the descriptive statistics (i.e., mean, standard deviation, minimum, and maximum) for the main explanatory and control variables of interest for the sample of Amazonian municipalities.

A3 Descriptive Statistics: Histograms

- Figure A1 shows the spatial distribution of mayoral margin of victory (2000).
- Figure A2 shows the spatial distribution of mayoral margin of victory (2004).
- Figure A3 shows the spatial distribution of mayoral margin of victory (2008).
- Figure A4 shows the histogram of mayoral margin of victory.
- Figure A6 shows the histogram of the logarithm of soybeans.
- Figure A7 shows the histogram of the logarithm of cattle.
- Figure A5 shows the histogram of the logarithm of deforestation.
- Figure A8 shows the histogram of protected area coverage.
- Figure A9 shows the histogram of the number of candidates.
- Figure A10 shows the histogram of annual mean rainfall.
- Figure A11 shows the plot of annual mean deforested area and change in mean deforested area.

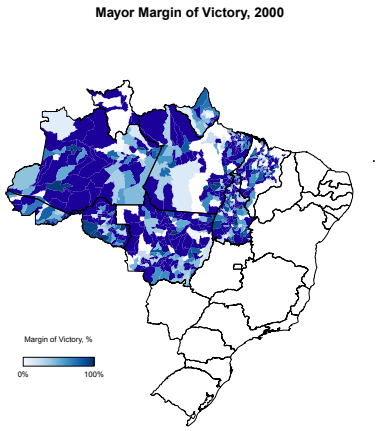

Figure A1: This map shows the spatial distribution of mayoral margin of victory for the election year 2000.

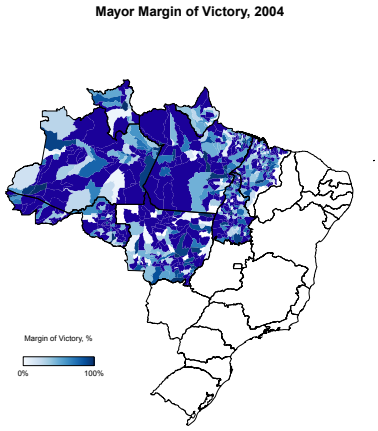

Figure A2: This map shows the spatial distribution of mayoral margin of victory for the year 2004.

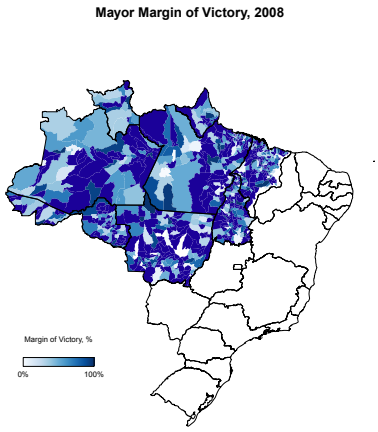

Figure A3: This map shows the spatial distribution of mayoral margin of victory for the year 2008.

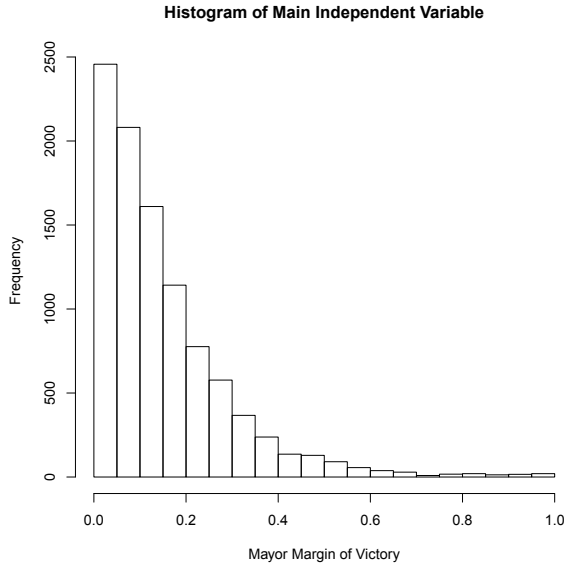

Figure A4: The histogram distribution of mayoral margin of victory.

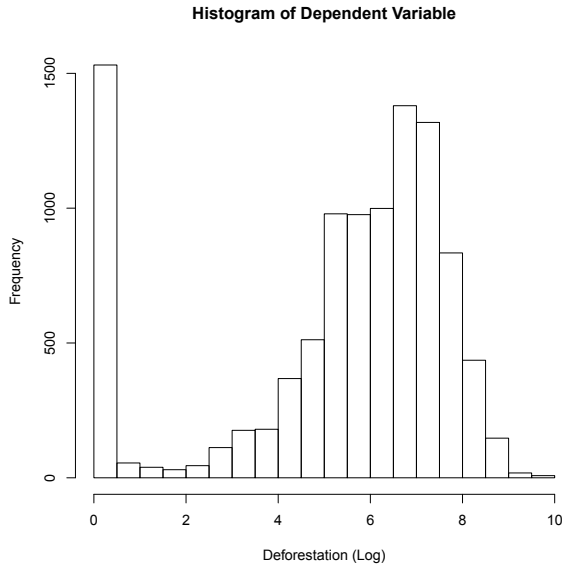

Figure A5: This figure shows the histogram distribution of the variable logarithm of deforestation.

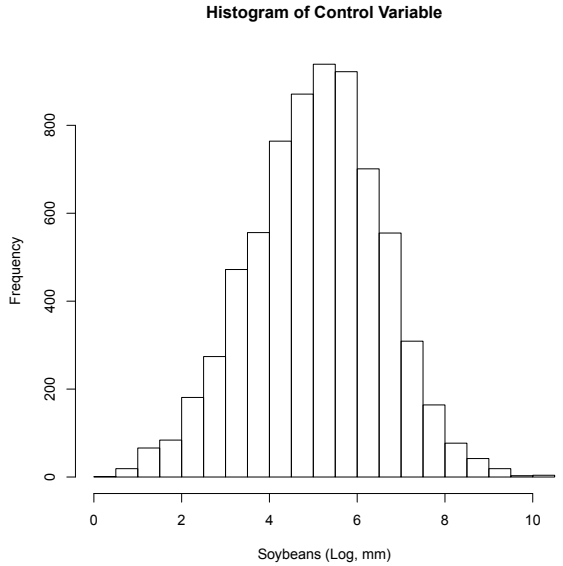

Figure A6: This figure shows the histogram distribution of the variable logarithm of soybeans.

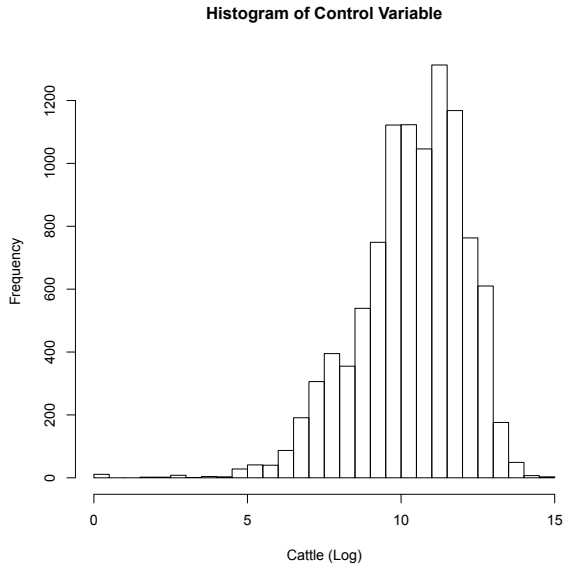

Figure A7: This figure shows the histogram distribution of the variable logarithm of cattle.

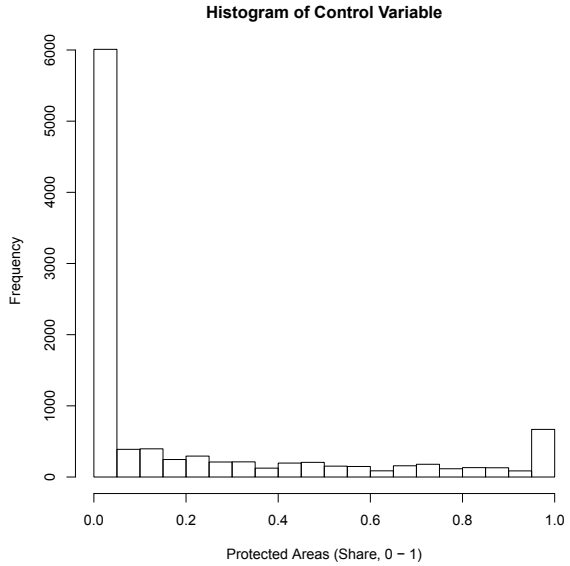

Figure A8: This figure shows the histogram distribution of the variable protected areas (0-1).

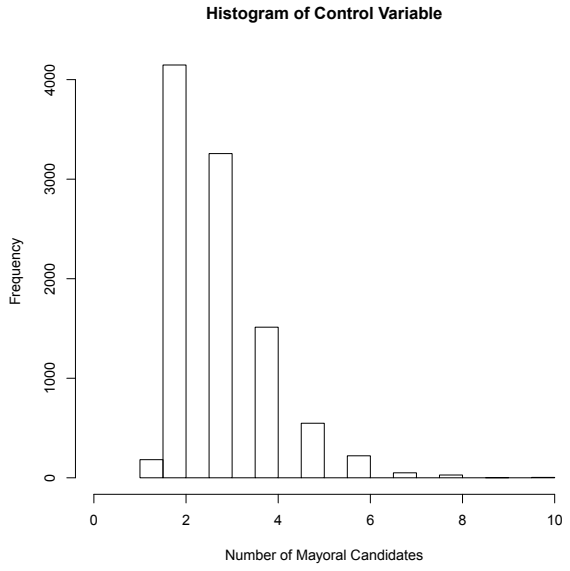

Figure A9: This figure shows the histogram distribution of the variable number of candidates mayor.

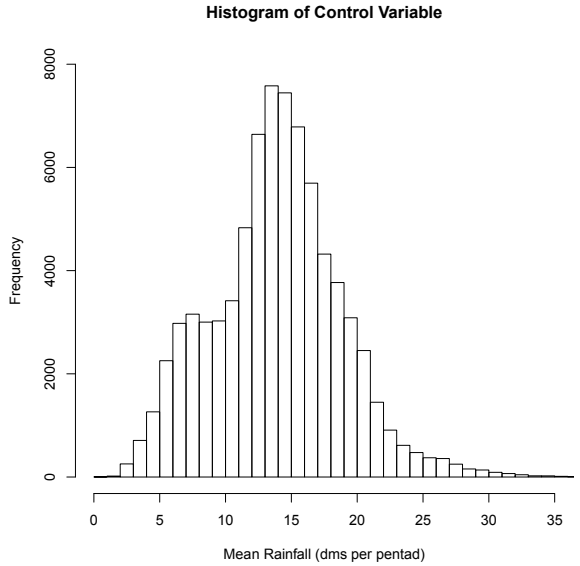

Figure A10: This figure shows the histogram distribution of the variable rainfall.

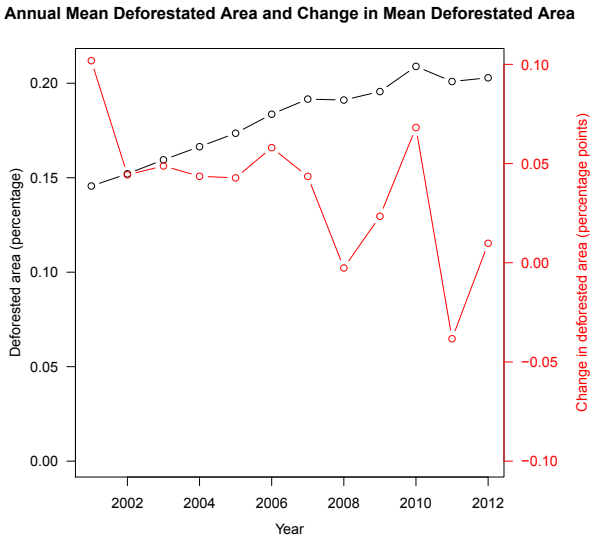

Figure A11: This figure shows the plot of annual mean deforested area and change in mean deforested area.

A4 Understanding the Median Voter

	Mean	Standard Deviation	Minimum	Maximum
Share Soy	0.029	0.249	0	4.393
Share Timber	0.021	0.145	0	2.352
Share Cattle	0.056	0.148	0	1.677
Share Agriculture	13.440	7.083	0.171	39.551

Table A3: This table shows the descriptive statistics (i.e., mean, standard deviation, minimum, and maximum) for the share of residents involved in the soy, timber, cattle, or agricultural industry across municipalities in the Amazon. *Source: *Instituto Brasileiro de Geografia e Estatistica* (IBGE).

	Median	Average	Standard Deviation	Minimum	Maximum
LAPOP 2014: Protect Environment v. Economic Growth (1 or 0)					
Median Voter (Amazon)	1	0.799	0.402	0	1
Median Brazilian	1	0.724	0.447	0	1
LAPOP 2017: Climate Change Serious Concern (1 to 4)					
Median Voter (Amazon)	4	3.606	0.864	1	4
Median Brazilian	4	3.669	0.745	1	4

Table A4: This table shows the summary statistics for LAPOP survey responses for questions concerning preferences for environmental management among residents in the Amazon.

A5 "Bureaucratic Packing" and Deforestation

(See next page.)

Table A5: Municipal Bureaucratic Appointments and Deforestation

	Dependent variable:				
	Deforestation (log)				
	(1)	(2)	(3)	(4)	(5)
New Municipal Personnel (log)	0.005**	0.004*	0.004*	0.004*	0.004*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Incumbent Win		0.002	0.002	0.000	0.004
		(0.004)	(0.004)	(0.004)	(0.006)
Cloud Coverage (log)			0.010***	0.008***	0.010***
			(0.002)	(0.002)	(0.003)
Mean Rainfall			-0.002	-0.003	-0.003
			(0.002)	(0.002)	(0.003)
Number of Mayoral Candidates				0.004	0.007
				(0.003)	(0.004)
Workers' Party (PT)'				-0.011	-0.017
				(0.009)	(0.011)
Existence of Environmental Councils				-0.001	-0.007
				(0.006)	(0.008)
Priority Municipality				0.120***	0.113***
				(0.014)	(0.017)
Protected Areas (0 - 1)				0.165***	0.152**
				(0.058)	(0.063)
Cattle (log)				0.044***	0.040**
				(0.014)	(0.016)
Soybeans (log)					-0.000
					(0.005)
Observations	8096	8074	8074	7969	5273

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A6: Bureaucratic turnover and deforestation, using the main set of panel fixed-effects models. Standard errors are clustered by municipality across all models.

A6 Political Competition and Bureaucratic Dismissals

(See next page.)

Table A7: Political Competition and Municipal Bureaucratic Dismissals

	Dependent variable:				
	Municipal Bureaucratic Dismissals (log)				
	(1)	(2)	(3)	(4)	(5)
Mayor Margin of Victory (0 - 1)	-0.148	-0.114	-0.094	-0.027	0.552
	(0.254)	(0.253)	(0.250)	(0.248)	(0.415)
Incumbent Win		-0.102	-0.113	-0.117	-0.166
		(0.078)	(0.078)	(0.077)	(0.130)
Cloud Coverage (log)			0.082**	0.076**	0.042
			(0.036)	(0.035)	(0.053)
Mean Rainfall			0.025	0.032	0.074*
			(0.025)	(0.025)	(0.044)
Number of Mayoral Candidates				0.040	0.118*
				(0.043)	(0.065)
Workers' Party (PT)'				0.118	0.491*
				(0.163)	(0.276)
Existence of Environmental Councils				0.069	0.194
				(0.093)	(0.134)
Priority Municipality				-0.550***	0.000
				(0.201)	(.)
Protected Areas (0 - 1)				1.556**	1.788*
				(0.738)	(1.070)
Cattle (log)				-0.009	-0.089
				(0.132)	(0.208)
Soybeans (log)					-0.005
					(0.074)
Observations	1,953	1,951	1,951	1,925	965

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A8: Margin of victory is not associated with an increase in bureaucratic dismissals, indicating bureaucratic turnover is not the mechanism.

A7 Shift-Share Instrument: Identification Assumptions

Although critics of instrumental variable designs have cast doubt on the validity of the estimation strategy in general, recent developments in shift-share instrumental variables prove to be an exception. A set of recent set of papers by Goldsmith-Pinkham, Sorkin, and Swift (2020); Adão, Kolesár, and Morales (2019); Borusyak, Hull, and Jaravel (2020) thoroughly explores the validity of the "Bartik" shift-share instrument variable (SSIV) used in this paper. The main identification assumption is that the instrument (i.e., predicted political competition) affects the outcome (i.e., deforestation) only the "treatment" (i.e., actual political competition), conditional on municipality and state-year fixed-effects. This is also known as the exclusion restriction assumption. Given the design of this SSIV for political competition, I can directly control for this potential threat of violation of the identification assumption. Shaukat (2019) proposed SSIV differs from standard shift-share frameworks, because the "shifts" affect predicted political competition non-monotonically. The effect is non-monotonic, because the same state-level "shift" in political competition can increase competition in some municipalities, while decreasing it in others, and the direction of the effect depends on the municipal-level "shares" themselves. For example, a positive "shift" in the incumbent party's popularity in state-level elections *increases* political competition in municipalities where an opposition party has a stronghold, yet it *decreases* competition in ones that favor this incumbent party (Shaukat, 2019). In contrast to standard shift-share frameworks that have become popular for research on immigration, the "shares" in the proposed instrument determine not only the *magnitude*, but also the *direction* of the change in predicted political competition in response to a state-level "shift." Standard shift-share instruments are constructed by taking the inner product of "shares" and "shifts," thus, the "shares" only determine the magnitude of the response to a "shift."

This assumption of non-monotonicity of the "shares" is critical, because it allows me to directly control for any endogenous effects driven by the "shares" themselves (Shaukat, 2019). In particular, I estimate a modified 2SLS model (i.e., modified Equations (4) and (5)) that controls for the predicted party vote shares as follows:

First-Stage:

$$\text{MoV}_{m,s,t} = \mu + \delta \text{ Predicted MoV}_{m,s,t} + \sum_{i=1}^{k} \theta_i \hat{s}_{i,m,s,t} + \gamma_m + \omega_{s,t} + \epsilon_{m,s,t} \quad (1)$$

Second-Stage:

$$\bar{y}_{m,s,t} = \alpha + \beta \text{ MoV}_{m,s,t} + \sum_{i=1}^{k} \theta_i \hat{s}_{i,m,s,t} + \gamma_m + \omega_{s,t} + \varepsilon_{m,s,t} \quad (2)$$

where, once again, Predicted $\text{MoV}_{m,s,t}$ is the predicted margin of victory instrument calculated in Equation (3), γ_m indicates municipality fixed-effects, $\omega_{s,t}$ is state-year fixed-effects, and $\sum_{i=1}^{k} \theta_i$ indicates the controls for predicted party vote shares. Controlling for the direct effects of the predicted party vote shares addresses any potential endogeneity of the "shares." And the results remain robust to this modification.

To further confirm the plausibility of the exclusion restriction, I conduct balance tests on "post-treatment" measures of municipal agricultural features and environmental regulations. As discussed in the main text, the inclusion of control variables in the 2SLS estimations could induce bias from conditioning on concomitant variables (Rosenbaum, 1984). Thus, instead of including them in the estimation, I directly test whether the proposed instrument predicts these other municipal-level variables. The results, presented in Table A9 below, show that the instrument is, indeed, balanced on climatological and agricultural variables. In addition, Table A10 shows balance on environment institutions and regulations.

Table A9: Balance Test for Exclusion Restriction: Climatological and Agricultural Variables

	(1)	(2)	(3)	(4)
	Cloud Coverage (log)	Mean Rainfall	Cattle (log)	Soybeans (log)
Predicted Political Competition (0 - 1)	0.029	-0.059	0.011	-92.721
	(0.115)	(0.101)	(0.038)	(83.778)
Observations	7,825	7,825	7,815	5,290

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A10: Balance Test for Exclusion Restriction: Environmental Institutions and Regulations

	(1)	(2)	(3)
	Existence of Environmental Councils	Priority Municipality	Protected Areas (0 - 1)
Predicted Political Competition (0 - 1)	0.005	-0.005	0.005
	(0.049)	(0.016)	(0.008)
Observations	7814	7825	7825

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A second threat to identification is the potential violation of the stable unit treatment value assumption (SUTVA) necessary for instrumental variables. This is especially of concern, given a "shift" in state-level party vote shares likely affects all municipalities within the state, precluding a "pure control" group without spillover effects. To illustrate this more clearly, Shaukat (2019) gives the example of patterns in the state government's allocation of resources across municipalities. There's considerable empirical evidence that in decentralized democracies, state and federal governments allocate financial resources to the more politically competitive municipalities (see for example Coêlho (2012); Gregor (2020)). Given a limit state budget (i.e., fixed level of resources), a state-level "shift" in political competition that increases political competition in some municipalities will, in turn, also affect (decrease) the allocation of state resources to other municipalities that experience a decrease in competitiveness. Hence a problem of spillover effects across units may be at play. Such concern for violation of SUTVA can be addressed by simply clarifying the interpretation of the coefficient, β, in the main models (Equation 5 in the main text and Equation 2 above) (Shaukat, 2019). β is the effect of an increase in margin of victory on deforestation *relative* to that experienced in other municipalities in the same state-year. β is, therefore, the estimated effect of margin of victory that is in the observed equilibrium allocation Shaukat (2019).

A8 Alternative Measures of Political Competition

Besides using this measure of margin of victory, I also test the robustness of the results a comparable measure of political competition (see Section 4.1) to pair with the analysis using the shift-share instrument variable. Besides these two measures, I calculate an additional measure of competition that captures the dispersion of party vote shares. Specifically, I compute the Herfindahl-Hirshman index (HHI) for incumbent and opposition parties as follows (see Shaukat (2019)):

$$\text{Dispersion}_{m,s,t} = 1 - \sum_{p=1}^{k} (s_{p,m,s,t})^2 \tag{3}$$

which takes the sum of squares of party vote shares in each municipality m and state s in year t. There are several benefits to using this HHI measure in place of margin of victory. First, this measure is less incumbent-centric and captures cases where a political candidate or party other than that of the incumbent's

may be the more relevant challenger (Shaukat, 2019). Second, although elections for mayor are conducted through dual-ballot majority rule, there could be cases where the locus of political competition is centered around more than two candidates. In other words, the incumbent is concerned about more than one opposition candidate. This HHI dispersion measure can more sufficiently account for these scenarios than does the measure of margin of victory. The results are robust to using this alternative measure.

A9 Tests of Robustness

- Table A11 shows the results when margin of victory is allowed to have nonlinear effects. In this table, a positive coefficient means a negative effect of margin of victory on deforestation, as the base category is margin of victory in excess of 50 percent.
- Table A12 shows from the main fixed effects models, using different subset of the sample. The column headings refer to the cut-off (floor) for forest area (in logarithmized square kilometers) excluded from the sample. In each model, I thus increase the floor and show that the results remain robust when municipalities with are excluded.
- Table A13 shows the main results Model 1 specification with list-wise deletion of Amazon states.
- Table A14 shows the main results with Models (1) - (5) specifications, excluding municipalities with mayors with uncommonly wide margins of victories (i.e., greater than 0.7).

	Dependent variable:				
	Deforestation (log)				
	(1)	(2)	(3)	(4)	(5)
Mayor Margin of Victory (0 - 0.05)	0.067***	0.064***	0.062***	0.062***	0.085**
	(0.024)	(0.024)	(0.024)	(0.024)	(0.039)
Mayor Margin of Victory (0.05 - 0.1)	0.073***	0.070***	0.069***	0.071***	0.081**
	(0.024)	(0.024)	(0.023)	(0.023)	(0.037)
Mayor Margin of Victory (0.1 - 0.2)	0.048**	0.045*	0.044*	0.045**	0.050
	(0.023)	(0.023)	(0.023)	(0.023)	(0.037)
Mayor Margin of Victory (0.2 - 0.3)	0.051*	0.049*	0.048*	0.047*	0.058
	(0.027)	(0.027)	(0.026)	(0.027)	(0.042)
Mayor Margin of Victory (0.3 - 0.5)	0.068***	0.064***	0.063***	0.061***	0.079**
	(0.023)	(0.023)	(0.022)	(0.022)	(0.037)
Incumbent Win		0.005	0.005	0.001	0.008
		(0.004)	(0.004)	(0.004)	(0.006)
Cloud Coverage (log)			0.016***	0.014***	0.016***
			(0.002)	(0.002)	(0.003)
Mean Rainfall (dms per pentad)			−0.010***	−0.011***	−0.012***
			(0.002)	(0.002)	(0.003)
Number of Mayoral Candidates				−0.004	−0.003
				(0.005)	(0.007)
PT				−0.016	−0.017
				(0.010)	(0.012)
Existence of Environmental Councils				0.004	0.016
				(0.008)	(0.011)
Priority Municipality				0.128***	0.115***
				(0.016)	(0.018)
Protected Areas (0 - 1)				0.184***	0.150**
				(0.068)	(0.073)
Cattle (log)				0.023*	0.022
				(0.012)	(0.015)
Soybeans (log)					−0.005
					(0.005)
Municipality Fixed Effects	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓
Observations	9,799	9,788	9,788	9,706	6,708
Note:					*p<0.1; **p<0.05; ***p<0.01

Table A11: This table shows the results when margin of victory is allowed to have nonlinear effects. The omitted category throughout is a margin of victory in excess of 50 percent of points. The model is linear and standard errors are clustered by municipality across all models.

	Dependent variable:					
	Deforestation (log)					
	(1)	(2)	(3)	(4)	(5)	(6)
Mayor Margin of Victory (0-1)	−0.076**	−0.073**	−0.068**	−0.068**	−0.067**	−0.062*
	(0.031)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)
Municipality Fixed Effects	✓	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓	✓
Observations	8,066	7,783	7,709	7,676	7,642	7,614
Note:						*p<0.1; **p<0.05; ***p<0.01

Table A12: This table shows the results from the fixed effects models for different subsets of forest density, as a robustness check to ensure the main results are not driven by a subset of municipalities with a particular amount of forest density. The main results are consistent across the subsets of the data.

	Dependent variable:								
	Deforestation (log)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mayor Margin of Victory (0-1)	−0.068**	−0.067**	−0.073***	−0.070**	−0.047***	−0.064**	−0.072**	−0.065**	−0.075**
	(0.027)	(0.027)	(0.028)	(0.032)	(0.018)	(0.031)	(0.029)	(0.027)	(0.031)
Municipality Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	9,514	9,595	8,995	8,117	7,367	8,030	9,123	9,616	8,035
Note:									*p<0.1; **p<0.05; ***p<0.01

Table A13: This table shows the Model 1 specification in the main results, with list-wise deletion of each of the nine states of the Amazon region. The effect of mayor margin of victory on deforestation holds across the models that drop each Amazonia Legal state.

	Dependent variable:				
	Deforestation (log)				
	(1)	(2)	(3)	(4)	(5)
Mayor Margin of Victory (0-1)	−0.045*	−0.044*	−0.040	−0.048*	−0.068*
	(0.025)	(0.025)	(0.025)	(0.026)	(0.037)
Incumbent Win		0.006	0.005	0.001	0.009
		(0.004)	(0.004)	(0.005)	(0.006)
Cloud Coverage (log)			0.016***	0.014***	0.016***
			(0.002)	(0.002)	(0.003)
Mean Rainfall (dms per pentad)			−0.010***	−0.011***	−0.012***
			(0.002)	(0.002)	(0.003)
Number of Mayoral Candidates				−0.004	−0.003
				(0.005)	(0.007)
Workers' Party (PT)				−0.017*	−0.017
				(0.010)	(0.012)
Existence of Environmental Councils				0.003	0.013
				(0.008)	(0.011)
Priority Municipality				0.128***	0.117***
				(0.016)	(0.019)
Protected Areas (0 - 1)				0.177**	0.147*
				(0.071)	(0.077)
Cattle (log)				0.025*	0.025
				(0.013)	(0.016)
Soybeans (log)					−0.004
					(0.005)
Municipality Fixed Effects	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓
Observations	9,704	9,693	9,693	9,615	6,657
Note:					*p<0.1; **p<0.05; ***p<0.01

Table A14: This table shows the Model 1 - 5 specifications in the main results, excluding municipalities with mayors with a acutely wide margin of victory (i.e., greater than 0.7).

A10 Testing for Spatial Correlation

Spatial Correlation: Rainfall and Cloud Coverage

	Dependent variable:	
	Mean Rainfall (dms per pentad)	Cloud Coverage (log)
	(1)	(2)
Mayor Margin of Victory (0-1)	0.070	−0.237
	(0.141)	(0.147)
Municipality Fixed Effects	✓	✓
State-Year Fixed Effects	✓	✓
Observations	9,799	9,799
Note:		*p<0.1; **p<0.05; ***p<0.01

Table A15: This set of estimations test for non-random assignment of margin of victory (MoV) in the panel regression results. In each model, a natural driver of rainforest cover –rainfall or cloud coverage– is regressed on the mayor's margin of victory in the previous election. The results show that there is no partial correlation between MoV and either variable; thus, the panel regression results are not driven by spatial correlation between MoV and drivers of rainforest growth or depletion.

A11 Testing Alternative Mechanisms

	Dependent variable:			
	Cattle (log)	Soybeans (log)	Embargo	Protected Areas (0 - 1)
	(1)	(2)	(3)	(4)
Mayor Margin of Victory (0-1)	0.114*	0.013	0.160	−0.014
	(0.062)	(0.117)	(0.177)	(0.012)
Municipality Fixed Effects	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓
Observations	9,789	6,774	6,101	9,799
Note:				*p<0.1; **p<0.05; ***p<0.01

Table A16: Analysis of alternative causal mechanisms. In this analysis, the dependent variables are intervening variables that could explain effects of political competition on deforestation. The model is linear and standard errors are clustered by municipality across all models.

	Dependent variable:				
	Deforestation (log)				
	(1)	(2)	(3)	(4)	(5)
Mayor Margin of Victory (0-1)	−0.100	−0.096	−0.093	−0.116*	−0.152
	(0.066)	(0.066)	(0.066)	(0.067)	(0.094)
Incumbent Win		0.007	0.007	0.002	0.010
		(0.004)	(0.004)	(0.005)	(0.006)
Cloud Coverage (log)			0.016***	0.015***	0.018***
			(0.002)	(0.002)	(0.003)
Mean Rainfall (dms per pentad)			−0.010***	−0.011***	−0.012***
			(0.002)	(0.002)	(0.003)
Number of Mayoral Candidates				−0.005	−0.003
				(0.005)	(0.007)
Workers' Party (PT)				−0.017*	−0.018
				(0.010)	(0.012)
Existence of Environmental Councils				0.005	0.015
				(0.008)	(0.011)
Priority Municipality				0.131***	0.115***
				(0.017)	(0.021)
Cattle (log)				0.028**	0.027*
				(0.013)	(0.016)
Soybeans (log)					−0.005
					(0.006)
MoV : GDPPC (2000)	0.243	0.213	0.229	0.326	0.465
	(0.348)	(0.346)	(0.343)	(0.343)	(0.465)
Municipality Fixed Effects	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓
Observations	9,703	9,692	9,692	9,610	6,668
Note:					*p<0.1; **p<0.05; ***p<0.01

Table A17: Margin of victory and deforestation, accounting for heterogeneous effects by monthly municipal GDP per capita (2000). The model is linear and standard errors are clustered by municipality across all models.

	Dependent variable:				
	Deforestation (log)				
	(1)	(2)	(3)	(4)	(5)
Mayor Margin of Victory (0-1)	−0.097	−0.102	−0.104	−0.103	0.010
	(0.132)	(0.132)	(0.129)	(0.131)	(0.191)
Incumbent Win		0.007	0.006	0.002	0.010*
		(0.004)	(0.004)	(0.005)	(0.006)
Cloud Coverage (log)			0.016***	0.015***	0.018***
			(0.002)	(0.002)	(0.003)
Mean Rainfall (dms per pentad)			−0.010***	−0.011***	−0.012***
			(0.002)	(0.002)	(0.003)
Number of Mayoral Candidates				−0.005	−0.003
				(0.005)	(0.007)
Workers' Party (PT)				−0.017*	−0.017
				(0.010)	(0.012)
Existence of Environmental Councils				0.005	0.016
				(0.008)	(0.011)
Priority Municipality				0.131***	0.117***
				(0.017)	(0.020)
Cattle (log)				0.027**	0.027*
				(0.013)	(0.016)
Soybeans (log)					−0.005
					(0.006)
MoV : Land Inequality (Gini)	0.041	0.047	0.055	0.041	−0.142
	(0.197)	(0.197)	(0.193)	(0.196)	(0.299)
Municipality Fixed Effects	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓
Observations	9,799	9,788	9,788	9,706	6,708
Note:					*p<0.1; **p<0.05; ***p<0.01

Table A18: Margin of victory and deforestation, accounting for heterogeneous effects characterized by land inequality (gini). The model is linear and standard errors are clustered by municipality across all models.

	Dependent variable:				
	Deforestation (log)				
	(1)	(2)	(3)	(4)	(5)
Mayor Margin of Victory (0-1)	−0.065**	−0.065**	−0.061**	−0.069**	−0.091**
	(0.027)	(0.027)	(0.027)	(0.028)	(0.043)
Incumbent Win		0.007	0.006	0.002	0.010
		(0.004)	(0.004)	(0.005)	(0.006)
Cloud Coverage (log)			0.016***	0.014***	0.016***
			(0.002)	(0.002)	(0.003)
Mean Rainfall (dms per pentad)			−0.010***	−0.011***	−0.012***
			(0.002)	(0.002)	(0.003)
Number of Mayoral Candidates				−0.004	−0.003
				(0.005)	(0.007)
PT				−0.015	−0.022
				(0.015)	(0.018)
Existence of Environmental Councils				0.004	0.014
				(0.008)	(0.011)
Priority Municipality				0.128***	0.115***
				(0.016)	(0.019)
Protected Areas (0 - 1)				0.188***	0.159**
				(0.069)	(0.074)
Cattle (log)				0.024*	0.023
				(0.012)	(0.015)
Soybeans (log)					−0.005
					(0.005)
PT:Mayor Margin of Victory	−0.057	−0.060	−0.059	−0.013	0.045
	(0.047)	(0.047)	(0.045)	(0.063)	(0.079)
Municipality Fixed Effects	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓
Observations	9,799	9,788	9,788	9,706	6,708
Note:					*p<0.1; **p<0.05; ***p<0.01

Table A19: Margin of victory and deforestation when mayor's PT affiliation is allowed to modify the association. The model is linear and standard errors are clustered by municipality across all models.

	Dependent variable:				
	Deforestation (log)				
	(1)	(2)	(3)	(4)	(5)
Mayor Margin of Victory (0-1)	−0.066**	−0.067**	−0.063**	−0.068**	−0.090**
	(0.028)	(0.029)	(0.028)	(0.029)	(0.045)
Incumbent Win		0.007	0.006	0.002	0.010
		(0.004)	(0.004)	(0.005)	(0.006)
Cloud Coverage (log)			0.016***	0.014***	0.016***
			(0.002)	(0.002)	(0.003)
Mean Rainfall (dms per pentad)			−0.010***	−0.011***	−0.012***
			(0.002)	(0.002)	(0.003)
Number of Mayoral Candidates				−0.004	−0.003
				(0.005)	(0.007)
PT				−0.017	−0.017
				(0.010)	(0.012)
Existence of Environmental Councils				0.004	0.014
				(0.008)	(0.011)
Priority Municipality				0.128***	0.116***
				(0.016)	(0.019)
Protected Areas (0 - 1)				0.188***	0.159**
				(0.069)	(0.074)
Cattle (log)				0.024*	0.023
				(0.012)	(0.015)
Soybeans (log)					−0.005
					(0.005)
PT State:Mayor Margin of Victory	−0.009	−0.011	−0.003	−0.018	−0.002
	(0.032)	(0.032)	(0.032)	(0.032)	(0.048)
Municipality Fixed Effects	✓	✓	✓	✓	✓
State-Year Fixed Effects	✓	✓	✓	✓	✓
Observations	9,799	9,788	9,788	9,706	6,708
Note:					*p<0.1; **p<0.05; ***p<0.01

Table A20: Margin of victory and deforestation when state governor's PT affiliation is allowed to modify the association. The model is linear and standard errors are clustered by municipality across all models.

Supplementary Appendix: References

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