Journal of Environmental Economics and Management 88 (2018) 345–365

Contents lists available at ScienceDirect

Journal of Environmental Economics and Management

journal homepage: www.elsevier.com/locate/jeem

Re-election incentives and deforestation cycles in the Brazilian Amazon ☆

Sharon Pailler

Clark University, Economics Department, 950 Main St. Worcester, MA 01610, USA

ARTICLE INFO

Article history:
Received 1 August 2016
Received in revised form
22 January 2018
Accepted 22 January 2018
Available online 4 February 2018

Keywords:
Forests
Election cycles
Institutions
Brazil
Campaign finance
Corruption

JEL codes:
D72
D73
Q23

ABSTRACT

Despite expansive research on Amazonian deforestation and its drivers, the role of local politics is not well understood. Using a panel data set that combines municipal-level deforestation and election data from 2002 to 2012, I estimate the effect of an incumbent mayor running for re-election on deforestation rates in election periods. I find that deforestation rates increase 8–10% in election years when an incumbent mayor runs for re-election, an amount equivalent to four percent of the total forest lost since the 2004 elections. Electoral deforestation cycles do not appear to be driven by changes in agricultural policy implementation and activity, but are linked to corruption and campaign finance, suggesting that weak institutional constraints facilitate electoral manipulation of forest resources. This phenomenon is not likely limited to Amazonian forests; re-election incentives could very well lead to misallocation of other natural resources in alternate geographies.

1. Introduction

The Amazon Basin is the largest rainforest in the world, is a globally important source of biodiversity and ecosystem services, and plays a critical role in international climate agreements (Foley et al., 2007). Since 1990, nearly 370,000 km^2 of the Brazilian Amazon, an area larger than Germany, has been deforested (INPE, 2014). Despite expansive research on the drivers and deterrents of Amazonian deforestation, there are few applications of formal economic models that explore how political incentives influence forest resource allocation. The political economy of deforestation in the Brazilian Amazon has thus received little attention in the economics literature. Accordingly, I explore how local politics influence deforestation in the Brazilian Amazon, specifically focusing on the extent to which re-election incentives induce deforestation in election years.

In election periods, politicians manipulate public spending and policy to boost popularity and secure votes. Election cycles have been observed in monetary and fiscal policy, as well as public goods provision (Nordhaus, 1975; Rogoff, 1990; Khemani, 2004). Only recently were election cycles documented in natural resources; Burgess et al. (2011) show a

☆ I am grateful for the invaluable guidance and feedback from Jacqueline Geoghegan, Wayne Gray, Lucija Mulhenbachs, Muhammed Nasir, Marc Rockmore, Mochamad Pasha, Sang Hoo Bae, Magda Tsaneva, Junfu Zhang, participants from the 2015 NEUDC and AERE summer conferences, and two anonymous reviewers. All errors are my own.

E-mail address: sharonpailler@gmail.com

https://doi.org/10.1016/j.jeem.2018.01.008
0095-0696/

substantial increase in illegal logging prior to local elections in Indonesia. Anecdotal evidence suggests that Amazonian forests may be similarly plagued; the Brazilian Minister of the Environment attributed a spike in deforestation to mayors ignoring illegal logging to garner votes for the 2008 mayoral elections (Balakrishnan, 2008).

Combining satellite-derived deforestation data with municipal election data from 2002 to 2012, I compare annual deforestation in municipalities where an incumbent mayor runs for re-election with municipalities absent an incumbent mayoral candidate. I include municipality and state-year fixed effects to control for factors that simultaneously influence electoral cycles and deforestation rates. Since Amazonian deforestation is primarily driven by agriculture, I examine whether electoral deforestation cycles are driven by agricultural policy implementation, agricultural constituency composition and interest group presence. I also consider the role of political connections, corruption and campaign finance in electoral deforestation cycles.

In election periods, deforestation rates are 8–10% higher in municipalities when an incumbent runs for re-election compared with municipalities without an incumbent running for re-election. This translates to 3545 km^2, or 4% of the total forest lost since the 2004 elections. Although agriculture is the biggest driver of deforestation, electoral deforestation cycles do not appear to be driven by agricultural activity or interests. Political affiliation between re-election eligible mayors and national-level politicians reduces the effect of elections on deforestation.

Corruption and campaign finance are strongly linked to electoral deforestation cycles. Municipalities with highly corrupt mayors running for re-election have approximately 50% more deforestation in election periods compared with municipalities without an incumbent running for re-election. This “corruption effect” accounts for all of the increase in deforestation when incumbent mayors run for re-election. Campaign contributions also play an important role in the electoral deforestation cycle. Self-funded campaign contributions are significantly positively related to election year deforestation; surprisingly, corporate and individual contributions are not. For each 1% increase in self-funded campaign contributions, there is a 0.017% increase in deforestation.

Brazil's political climate is notoriously corrupt, with dubious campaign finance dynamics (Gingerich, 2014). This, coupled with re-election incentives and the ability to clandestinely gain from forest resources, creates perfect conditions for electoral deforestation cycles. Because corrupt politicians receive greater private benefits from holding office, they have more incentives to remain in office and misallocate resources to assure re-election, leading to larger resource distortions (Shi and Svensson, 2006). Mayors may specifically exploit forest resources in election periods because they can gain valuable campaign funding without the voting population detecting resource misallocation, since an increase in deforestation above the norm is not easily observed.

Prior work on the political economy of forest resource use focuses primarily on decentralization, and the characteristics of participants and institutional arrangements (Andersson et al., 2006; Ribot et al., 2006; Agrawal, 2007; Andersson and Gibson, 2007). Some of this work demonstrates that decisions made by local politicians determine the effectiveness of decentralized forest management, and that decentralization leads to sustainable forest management only when local politicians have the political or financial incentives, ultimately suggesting that local politicians manipulate forest resources for political advancement (Gibson and Lehoucq, 2003; Andersson et al., 2004).

Local politics undoubtedly influence forest management. Here I apply an economic framework to understand how local political processes create incentives to manipulate forest resources, and show that local electoral processes lead to increased deforestation in the Brazilian Amazon. This phenomenon is not likely limited to Brazil given that deforestation cycles have been observed elsewhere (Burgess et al., 2011). Compared with Brazil, many forest-rich countries have weaker institutions and lesser capacity to prevent electoral deforestation cycles. Election cycles are also not likely limited to forest resources, re-election incentives could instigate misallocation of other natural resources such as minerals or oil.

2. Background

2.1. Deforestation in the Brazilian Amazon

Brazil has been characterized a “world leader” in deforestation (Nepstad et al., 2009). Deforestation contributes to climate change, biodiversity loss and reduced rainfall (Shukla et al., 1990; Skole and Tucker, 1993; Foley et al., 2007; Nepstad et al., 2009), and recent literature points to the adverse public health effects of deforestation, such as increased malaria incidents (Pattanayak and Pfaff, 2009; Garg, 2014). Historic drivers of Amazonian deforestation are diverse. Central government policies in the 1960s promoted large infrastructure projects and settlement in the Amazon region, initiating a surge of deforestation through the 1980s (Binswanger, 1991; Alston et al., 2000; Araujo et al., 2009). Since the 1980s, agricultural credit and subsidies, coupled with globalizing markets and improved transportation systems, encouraged further economic development activities that accelerated deforestation (Hargrave and Kis-Katos, 2012). Currently, industrial scale agriculture, primarily cattle ranching, is the biggest driver of deforestation in the Amazon (Fearnside, 2005; Nepstad et al., 2009; Hargrave and Kis-Katos, 2012). Most of Brazil's deforestation over the past decade has been attributed to illegal activity; as much as 90% of deforestation from 2000 to 2012 was illegal (Lawson et al., 2014).

Economic development remains one of Brazil's top priorities, however given the Amazon's critical role in carbon sequestration and biodiversity preservation, protecting Amazonian forests is also of utmost importance. After record-breaking deforestation in the 1990s and early 2000s, Brazil implemented a number of policies designed to protect its forests (Arima

et al., 2014). Protected areas were widely established and the 1965 forest code was modified, increasing the proportion of forest cover landholders were required to maintain on their property (Nolte et al., 2013). In 2004, the government instituted the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon, which included a satellite-based system to monitor deforestation activity and issue citations against illegal deforestation activity. Since 2006, global soy traders have boycotted soy grown on deforested land. In 2008, the government began a municipality "blacklist", penalizing municipalities with the highest rates of deforestation. Blacklisted municipalities have more stringent environmental monitoring and licensing requirements, and are subject to credit restrictions and limited economic activity with embargoes imposed on local firms. While these efforts to curb deforestation in the Amazon have proven to be successful (Assunção et al., 2013a; Arima et al., 2014; Assunção and Rocha, 2014), a plummeting economy coupled with relaxed environmental regulation have led to an increase in deforestation in recent years (Watts, 2015; Garcia-Navarro 2016).

2.2. Election cycles

Nordhaus (1975) was the first to formally model the political business cycle (PBC). In Nordhaus's PBC model, voting is based on the recent past (with a continuous decay rate) rather than an average over the prior political term. Prior to elections the incumbent adopts expansionary monetary policy, generating a favorable economic boom preceding the election (Nordhaus, 1975). Favorable economic conditions improve the politician's popularity in advance of the election; once re-elected the politician can return to less popular, contractionary monetary policy without risking losing his/her seat. True to Nordhaus' PBC model, there is evidence of election cycles in inflation rates and monetary policy, inflation rates tend to be higher after elections and monetary growth tends to increase prior to elections (Drazen, 2001).

Although PBCs are "readily" observed, several scholars criticized Nordhaus' model because 1) rational voters should not continue to fall for predictable, readily observable business cycles and 2) in the PBC model, voting is based on expectations of future periods, not pre-election improvements (Drazen, 2001; Rogoff, 1990). To address these issues, Rogoff (1990) developed a model that considers election cycles a mechanism for incumbent politicians to signal their ability through fiscal policy, given different candidate competencies and asymmetric information about those competencies. Incumbent politicians manipulate fiscal policy in ways voters like to demonstrate their political competence in election years, but in doing so, generate a deficit following the election (Rogoff, 1990). Rogoff argued that election cycles are not necessarily bad, and may be a socially efficient mechanism for voters to gain information about the competence of a politician (i.e. there are more costly ways of signaling). There is evidence that, as voter awareness and information symmetry increases with age of a democracy, election cycles are observed less (Akhmedov and Zhuravskaya, 2004). In other words, as voters become more aware of electoral processes (through experience and media), electoral distortions are less effective.

Since Rogoff's model, a broad literature demonstrates that politicians implement policies and spending patterns favored by the voting population in order to boost their popularity and chances of re-election (Nordhaus, 1975; Rogoff, 1990; Drazen and Eslava, 2010). For instance, police hiring in large US cites increases significantly in election years (Levitt 1997). Elections induce surges in agricultural credit and electricity provision in India (Cole, 2009; Baskaran et al., 2015). In Colombia and Mexico, infrastructure spending and construction increase prior to elections (Gonzalez, 2002; Drazen and Eslava, 2010). In Brazil, local expenditures increase and local tax revenues decline, and significantly more environmental licenses are issued to firms in municipal election years (Ferraz, 2007; Sakurai and Menezes-Filho, 2011).

Few examine election cycles in natural resource exploitation, excepting Burgess et al. (2011), who show an increase in illegal deforestation preceding local elections in Indonesia. Although this work documents an electoral deforestation cycle in forest resource allocation, it is not clear what political processes drive these cycles. The authors suggest it may be that local politicians liquidate forest resources to extract maximum rents prior to leaving office, or local politicians may allow illegal logging to boost popularity among voters, or exploit forest resources to finance their campaigns (Burgess et al., 2011). Because it is not clear which politicians run for re-election, it is impossible to determine whether or not Indonesia's deforestation cycle is driven by re-election incentives. I build on this work by explicitly linking increased deforestation to re-election eligible mayors, as opposed to mayors who are leaving office. With detailed election data available in Brazil, it is possible to identify when and where an incumbent mayor runs for re-election, and specifically estimate the effect of election incentives on deforestation.

Forests have characteristics which render them particularly vulnerable to electoral manipulation. Activities that lead to deforestation provide immediate local benefits to the voting population; but the costs of deforestation are widespread and may take years to realize. In this sense, deforestation may allow politicians to provide benefits to the voting population in election years while avoiding budget deficits following elections. Increased deforestation activity is also not immediately observable, therefore deforestation may be more easily obscured compared with other forms of electoral manipulation, such as public spending (Burgess et al., 2011; Cisneros et al., 2013). Increasing access to forests may be an easy way for politicians to attract voters compared with other goods and services provision; many individuals have the ability to exploit, and benefit from access to, forest resources (Kolstad and Søreide, 2009). Given these qualities, forests present a unique opportunity to examine how election incentives influence natural resource allocation, given that election cycles likely manifest differently in natural resources compared with other public goods.

2.3. Potential effects of local elections on deforestation

Brazilian mayors have authority over municipal priorities, resource allocation and policy implementation (Brollo and Nannicini, 2012; Ferraz and Finan, 2011). Although environmental policy is set and largely enforced at the national level, Brazilian mayors have substantial capacity to influence municipal-level deforestation (Fearnside, 2003), and there are several mechanisms by which mayors could manipulate forest resource allocation in election years to increase their popularity and chances of re-election. Mayors could appeal to the general public by modifying policies or processes that broadly affect the population, or they could target benefits to smaller special interest groups. Rather than manipulating policies, mayors could appeal to voters through campaign strategy. Samuels (2001a, 2002) describes this as an effective approach to build political support since mayors have more discretionary power over campaign spending compared with more restrictive state-wide policies.

Election cycle theory suggests that resources are distorted to appeal to voters. Politicians can appeal to the general public or target specific groups of voters. In the case that mayors appeal widely to the general public, they may attempt to create an economic boom in election years by encouraging agricultural activity, which would increase deforestation rates. For instance mayors can facilitate agricultural credit or subsidy acquisition (Ferroukhi, 2003), or refrain from enforcing environmental regulation. In 2008, the Brazilian Environment Minister directly attributed increased deforestation rates to reduced enforcement immediately prior to the upcoming local elections, remarking “No mayor wants to be obstructive at such times” (Goldemberg, 2008).

Mayors could also target certain groups or individuals with special favors in exchange for political support. Khemani (2004) finds that during election periods in India, policies are distorted in an election cycle that specifically favor “critical constituencies”, rather than the general population. In Brazil, local politicians conspire with firms, upholding false titles and paperwork, so that firms are in compliance with legal deforestation limits (Wallace, 2007; Instituto Pólis, 2008), and grant licenses for deforestation-related activity (Ferroukhi, 2003). In this case, mayors could specifically provide a small group of influential individuals with increased access to forests in election periods in exchange for political support that the mayor can then use appeal to the broader voting population.

Finally, mayors could appeal to voters not through policy, but through election campaigns. Samuels (2001a, 2001b, 2002) demonstrates that campaign finance in Brazil enables politicians to promote themselves and their messages to the general public, and the amount of campaign funding is an important determinant of election outcomes. Samuels (2002) argues that campaign funding is even more effective for incumbent politicians than policy distortions or special interest projects because such efforts may not benefit the desired voting population and they may have to share the credit with other politicians. Campaign funds, on the other hand, are exclusively managed by the politician and can be directed to whomever, however the politician sees fit, thus targeting voters who may not benefit from specific public works projects (Samuels, 2002). Forests could serve as a mechanism to fund campaigns. Politicians may clear forests themselves to supplement their campaign budget, or they may accept bribes from others in exchange for forest access. Because deforestation is not easily observed by the voters, politicians can exploit forests to augment campaign resources without public scrutiny.

2.4. Brazil's political context

Brazil is a relatively new democracy, established in 1985 after several decades of military rule. The federal government has executive, legislative and judicial branches. There are 26 states and 5570 municipalities, each with an autonomous government, and governed by its own elected representative (governor or mayor, respectively). States and municipalities can enact their own constitutions and laws, and collect taxes, although not all municipalities collect taxes, and those that do collect very little (Brollo et al., 2013). Presidential, gubernatorial and mayoral elections occur every four years. The presidential and gubernatorial races occur in the same year and mayoral races occur two years after presidential races. Prior to 1997, mayors were only allowed to run for a single term, therefore the first elections where an incumbent mayor could run for re-election was in 2000. This, coupled with the fact that Brazil is a relatively new democracy, makes it a good context to study election cycles. As democracies age, information asymmetries diminish, and electoral manipulation is less observed (Akhmedov and Zhuravskaya, 2004).

Mayoral terms last four years (last election was held in 2016). Mayors may be re-elected for a second consecutive term, and may run again for a third term after a one-term absence (Ferraz and Finan, 2011). While most first-term mayors run for a second term, less than half are re-elected; the lack of an incumbency advantage implies that first-term mayors must satisfy the voting population in order to be re-elected a second term (Ferraz and Finan, 2011).

Individuals above age 18 are required to vote. Municipalities with populations less than 200,000 voters are under a single-ballot rule system, where one round of elections is held and the candidate with the highest number of votes is elected into office. Municipalities with populations greater than 200,000 voters follow a dual-ballot system that has two rounds of elections. In the first round, if no single candidate earns more than 50% of the votes, then a second round is held, where the two candidates with the highest number of votes compete for office (Ferraz and Finan, 2011; Brollo and Nannicini, 2012; Brollo et al., 2013).

Brazil has a multi-party system, with currently more than 30 registered parties. Political parties, in general, do not have strong ideologies, and candidates often switch parties throughout their careers. As such, Brazil's electoral system favors individual politics rather than partisan politics (Samuels, 2001a, 2002). The presence of multiple parties in Brazil encourages

them, especially smaller parties, to cooperate and form coalitions. Coalition size, heterogeneity and internal dynamics influence elected candidates and the policies s/he promotes (Raile et al., 2011). Elected leaders "reward" coalition members with appointments to the cabinet, and provide political support to candidates and legislation within coalition parties (Raile et al., 2011). Mayors affiliated with state and presidential coalitions receive significantly more benefits (pork) than those who are not (Brollo and Nannicini, 2012; Bugarin and Ubrig, 2012). Coalition parties are not consistent, and change from one term to the next.

3. Empirical approach and data

3.1. Empirical approach

The primary focus of this analysis is to test if, and how much, re-election incentives generate an electoral deforestation cycle in the Brazilian Amazon. To do this, I compare election-period deforestation rates in municipalities where an incumbent mayor runs for re-election with deforestation rates in municipalities where the incumbent mayor is leaving office (is not running for re-election). Because deforestation may be driven by broader temporal trends and municipal-level characteristics that could simultaneously influence electoral cycles, I include municipality and state-year fixed effects to control for these factors. The effect of election incentives on deforestation is thus estimated using variation within a given municipality, while controlling for state-level time trends. This general approach has been widely applied in election cycle analysis (Akhmedov and Zhuravskaya, 2004; Cole, 2009; Burgess et al., 2011; Baskaran et al., 2015). The formal specification is

$$deforest_{mt} = \mu_m + \delta_{st} + \sum_{k=t-2}^{t+2} \sigma_k Incumb_{mk} + \varepsilon_{mt}, \quad (1)$$

where $deforest_{mt}$ is the log of the area (km^2) deforested in municipality m in time t ; μ_m denotes municipality fixed effects, which control for time-invariant, municipal-level characteristics; δ_{st} denotes state-time fixed effects, which control for macro-level factors that may influence the dependent variable, such as price of agricultural products or state-wide policy change; and $Incumb_{mt}$ is a dummy variable equal to one when an incumbent is running for office in a given municipality in an election year. The σ_k coefficient is the difference in deforestation in election years between municipalities with and without incumbent mayors running for re-election (Fig. 1). If incumbent mayors running for re-election increase forest resource allocation in election years, then we would expect a significant, positive σ_k coefficient. Following Burgess et al. (2011), specifications include two lags $(t + 2)$ and leads $(t - 2)$ of the incumbent election year dummy. It is possible that policy distortions occur in the time period leading up to elections, so deforestation rates may change prior to the election year (as in Burgess et al., 2011). Likewise, policy distortions may not immediately translate to increased deforestation, so changes in deforestation rates could be observed after the election period.

Agriculture is by far the greatest driver of deforestation in the Brazilian Amazon, and deforestation cycles may be driven by politicians encouraging agricultural activity, or ignoring illegal deforestation that occurs as a result of increased agricultural activity. I therefore test for election cycles in the following variables: agricultural credit, municipal-level agricultural GDP, and environmental enforcement. I use the main specification just described, but change the dependent variable. If electoral deforestation cycles are driven by mayors stimulating agricultural activity to retain their seats in office, then we would expect higher levels of agricultural credit and agricultural GDP, and lower levels of environmental enforcement in election years when an incumbent mayor runs for re-election.

Because roads facilitate agricultural and economic activity, and there is a clear link between road density and deforestation (Chomitz and Gray, 1996), I also estimate the effect of road density on deforestation. The absence of data documenting annual changes to transportation systems in the Amazon precludes estimating whether or not incumbents running for re-election establish more roads in election periods. Rather, I estimate whether road density in a given municipality significantly influences electoral deforestation cycles. To test the effect of road density, I include municipal-level road density, interacted with the incumbent dummy variable and its lags and leads. The coefficient on the interaction terms will identify the marginal effect of road density on election-period deforestation where incumbents run for re-election.

Incumbent politicians seeking re-election may target benefits to specific groups of voters, rather than appealing to the general voting population (Grossman and Helpman, 1994; Bardhan and Mookherjee, 2000; Khemani, 2004). Prior research identifies a specific interest group effect in election cycles (Khemani, 2004), and demonstrates that constituency

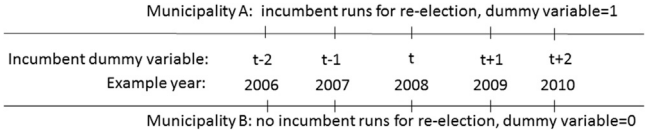

Fig. 1. Illustration of the variation in deforestation that σ_k captures: differences in deforestation in municipalities with and without an incumbent mayor running for re-election.

composition can influence election outcomes (List and Sturm, 2006). A stronger agricultural constituency or the presence of organized agricultural groups could influence the magnitude of electoral deforestation cycles that are driven by changes in agricultural policy in election years. To test whether agricultural constituencies and interest groups influence electoral deforestation cycles, I include variables for the number of individuals in the agriculture labor force and the number of agricultural organizations, interacted with the incumbent dummy variable and its lags and leads. The coefficient on the interaction terms will identify the marginal effect of agricultural constituency and interest group size on deforestation in and around election years.

Affiliation with the government coalition may influence the extent to which a mayor distorts forest resource allocation. Brollo and Nannicini (2012) found that mayors belonging to a government coalition party (i.e., a political party with a cabinet seat) receive nearly 1/3 higher federal transfers for infrastructure than mayors who do not, and argue that the central government strategically provides more discretionary funds to politically aligned mayors in order to help them in election periods (and to punish mayors who are not politically aligned). Preferential treatment of government coalition members may have differential effects on forest resource allocation in election periods. To test the role of affiliation with the government coalition, I include a dummy variable equal to one in years when the incumbent mayor belongs to the government coalition and its interaction with the incumbent run dummy variable and its leads and lags.

Because corrupt mayors obtain more private benefits from office through rent-seeking activity, they have more incentives to distort resources to win re-election, leading to greater election cycles (Shi and Svensson, 2006). To estimate the role of corruption in electoral deforestation cycles, I include and interact a dummy variable that indicates a mayor is highly corrupt in a given municipality in a given term with the incumbent dummy variable and its leads and lags. Mayors are deemed corrupt if at least one corrupt action is documented in a municipality's fiscal audit during the mayor's tenure. I also examine the relationship between campaign contributions and deforestation. Samuels (2002) shows that Brazilian politicians trade political favors for campaign contributions. Mayors may allow access to forests in exchange for campaign funding. Distinguishing between contributions from corporations, individuals and the politicians' self-funding, I interact the log value of contributions received with the incumbent dummy variable and its lags and leads. The coefficients on the interaction terms will identify the link between campaign contributions and deforestation in and around election years.

In each of these models, I include controls for time-variant factors that may influence observed deforestation such as: mayor education, population, precipitation, and forest area unmeasured due to cloud cover. I also include controls for agricultural GDP, agricultural credit, enforcement activity, whether or not the municipality has been blacklisted, and protected/indigenous areas. Many control variables are potentially endogenous, and are indeed also considered to be possible mechanisms; I therefore test specifications with the full set of control variables and specifications that omit potentially endogenous variables. For the primary specification and robustness checks, I also estimate specifications with one-year lagged values of potentially endogenous control variables.

Although the data do not facilitate rigorous analysis, I explore the dynamics between deforestation and voting behavior, which can provide some insights about electoral deforestation cycles in the Brazilian Amazon. Of course, numerous factors simultaneously determine deforestation rates and voting behavior, and such a relationship would be best explored with an appropriate instrument. Without such an instrument, I am obliged to use the available data and empirics. The following equations test this relationship:

$$votemargin_{imy} = deforest_{my} + ed_i + media_m + \delta_{sy} \tag{2}$$

Here, *votemargin* is the percentage of votes that the incumbent mayor (i) won (or lost) by in the second term election in a given municipality (m) and election year (y). In these specifications, only election years and municipalities in which an incumbent mayor runs for re-election are observed, so I cannot control for municipal-wide characteristics with a municipality fixed effect. Instead, to control for municipal-level deforestation patterns I use a normalized measure of deforestation, $\frac{deforestation\ increment_{mt} - mean\ deforestation_m(2000-2013)}{standard\ deviation\ deforestation_m(2000-2013)}$, which is the observed deforestation in municipality m in time period t minus the average deforestation in municipality m across the time period 2000–2013 divided by the standard deviation of deforestation between 2000 and 2013 (Assunção et al., 2013a). I include a dummy variable equal to one when a mayor has completed secondary school to control for education level, dummy variables equal to one when a municipality has a radio station and newspaper to control for media presence (or lack thereof), and state-election-year fixed effects (δ_{sy}). Using a logit model, I also estimate whether or not deforestation influences the probability of an incumbent mayor winning the second term election:

$$win^*_{imy} = deforest_{my} + ed_i + media_m + \delta_{sy}. \tag{3}$$

Where

$$win_{imy} = \begin{cases} 1 & if\ \ win^*_{imy} > 0 \\ 0 & if\ \ win^*_{imy} \leq 0 \end{cases},$$

and all other variables are defined as in the previous equation.

Table 1
Data sources.

Variable	Years	Source	Website
Agricultural GDP	2002–2012	IBGE	http://www.sidra.ibge.gov.br
Population	2002–2012	IBGE	http://www.ibge.gov.br
Road density	2015	IBGE	http://www.ibge.gov.br
Agricultural labor & organizations	2006	IBGE 2006 Agricultural Census	ftp://ftp.ibge.gov.br/Censos/
Deforestation	2002–2013	INPE PRODES	http://www.dpi.inpe.br/prodes/index.php
Fire	2002–2012	INPE PRODES	http://www.dpi.inpe.br/proarco/bdqueimadas/
Precipitation	2002–2012	TRMM	http://mirador.gsfc.nasa.gov/collections
Election data	2000–2012	Tribunais Regionais Eleitorais	http://www.tse.jus.br/eleicoes/estatisticas
Embargoed properties	2006–2012	IBAMA	https://servicos.ibama.gov.br
Environmental fines	2002–2012	IBAMA	https://servicos.ibama.gov.br
Blacklisted municipalities	2008–2012	MMA	http://www.mma.gov.br/florestas/
Protected and indigenous areas	2002–2012	MMA	http://mapas.mma.gov.br
Rural credit	2002–2012	Banco do Brasil	http://www.bcb.gov.br
Settlements	2002–2012	INCRA	http://www.incra.gov.br
Corruption	2003–2009	Brollo et al., 2013	https://sites.google.com/site/fernandabrollo

3.2. Data

3.2.1. Election data

Election data for the 807 municipalities in the nine states of the Brazilian Amazon are available online through the National Electoral Office (Tribunal Superior Eleitoral) (Table 1). These data include information on the candidate, party and coalition affiliations, source and amount of campaign contributions, and election outcomes. I use data from the 2000, 2004, 2008 and 2012 municipal elections, matching candidates by name and birth date to determine in which municipalities and elections an incumbent mayor runs for re-election. I examine 256 incumbents running in the 2004 elections, 340 incumbents running in the 2008 elections, and 301 incumbents running in the 2012 elections.

3.2.2. Deforestation data

Annual municipal-level deforestation data are available from years 2000–2013 through the National Institute for Space Research's (INPE) Project for Monitoring Deforestation in the Legal Amazon (PRODES) (Table 1, Fig. 2). PRODES collects deforestation data for 807 municipalities in nine states through satellite imagery over 12 months, from August 1 to July 31. Because August and July fall in the dry season, this period has the least amount of cloud cover, yielding the clearest satellite imagery. Deforestation measures are determined by comparing forest cover from one year to the next. PRODES measures only clear-cut deforestation of areas greater than 6.25 ha; degraded areas and selective logging are not included in the deforestation measure (INPE, 2013). PRODES reports the annual increment of deforestation as well as the total area of forest cleared and remaining forest cover.

Deforestation in the Brazilian Amazon is a lengthy process that generally begins in the rainy season (December–May), when vines and small trees are cleared to make it easier and safer to remove large trees at the beginning of the dry season (May–June). Once large trees have been removed, the remaining biomass is burned (July–September), and grasses are planted for pasture (INPE, 2013). Land is considered deforested when formerly forested land is completely transformed to an alternate land use (INPE, 2013). Because the deforestation process is not complete until after July 31, it appears in the following year's deforestation measurement.

Satellite imagery of fire occurrences in Brazil, available through INPE, illustrates the timing of the final stages of deforestation.[1] The distribution of monthly fire incidents in the Amazon provides clear evidence that burning, the final stage of the deforestation process, occurs in the latter half of the calendar year, which falls in the following year's deforestation measure (Fig. 3). As such, I use the following year's deforestation measure ($t+1$) for a given year (t) throughout this analysis.

I include municipalities that have more than 10% forest cover within the sample period (2002–2013) as in Hargrave and Kis-Katos (2012). This removes 189 municipalities from the original sample of 807 municipalities.

3.2.3. Agricultural variables

The amount of rural credit issued within a municipality each year is available through the Banco do Brasil (Table 1). Environmental enforcement data include annual deforestation-related embargoes and environmental fines for each municipality, available from the Brazilian Institute of Environment and Renewable Natural Resources' (IBAMA) online database:

[1] I used ArcGIS to project fire data into the South America Equal Area Conic projection and the spatial join tool with an administrative map, similarly projected, to identify municipal-level fire incidents by month and year.

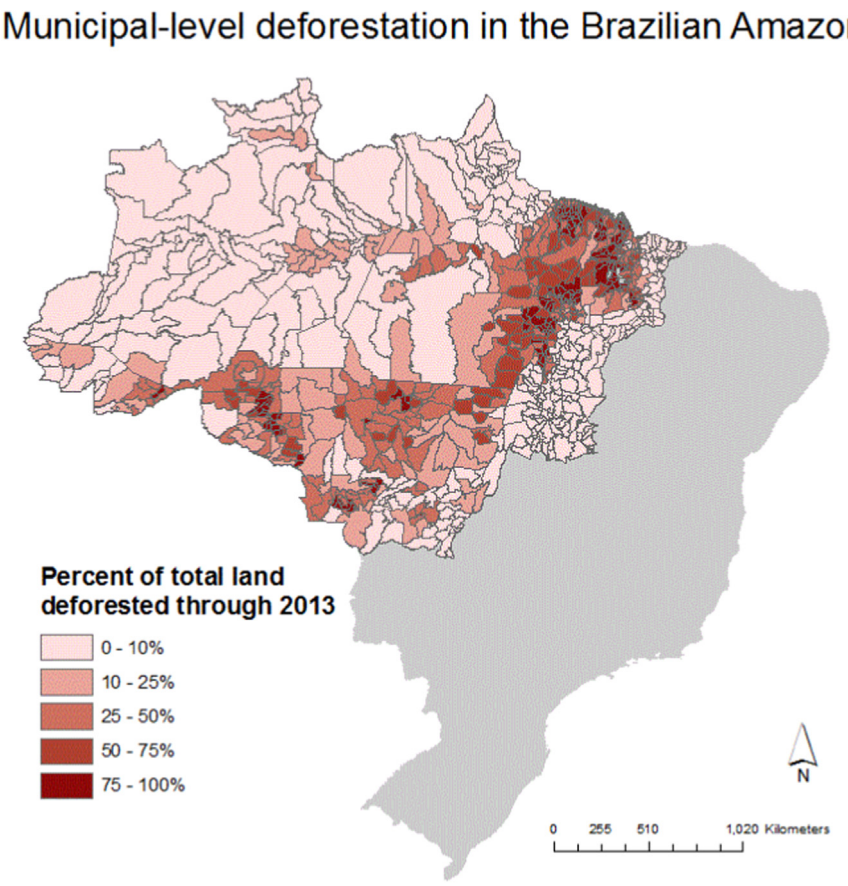

Fig. 2. Cumulative total municipal-level deforestation in the Brazilian Amazon.

Consulta Pública de Autuações Ambientais e Embargos. The Instituto Brasileiro de Geografia e Estatística (IBGE) provides a current (2015) map of paved and unpaved roads across Brazil; these data were used to compute road density.[2] Variables that estimate effects of agricultural interests at the constituency and organizational level come from Brazil's 2006 agricultural census (IBGE).

3.2.4. *Corruption data*

Corruption data are available for 276 Amazonian municipalities for a subset of mayoral terms (436 municipality-term observations) through work published by Brollo et al. (2013). Brazil began an anti-corruption campaign in 2003 where, several times per year, a subset of 50–60 municipalities are randomly selected to undergo an audit of fiscal spending since 2001 (Ferraz and Finan, 2011; Brollo et al., 2013). Brollo et al. (2013), similarly to Ferraz and Finan (2011), reviewed these audits and coded them based on the number and severity of "irregularities" documented. Each severe irregularity indicates a corrupt act that occurred during a given mayor's term in office, such as using false receipts and over-invoicing to divert pubic funds (Ferraz and Finan, 2011; Brollo et al., 2013). The data, provided through their published work, includes a dummy variable for municipalities in a given term that have at least one severe irregularity noted in the audit.

3.2.5. *Control variables*

I include control variables for biophysical attributes that potentially influence deforestation rates over time. Precipitation influences deforestation through agricultural productivity as well as forest fires (Laurance et al., 2002). I include a control variable for average annual precipitation rate (mm/hr), since it is a time-variant measure that varies by municipality, and can influence deforestation rates.[3] I control for the amount of area in a municipality that is unobserved through the

[2] I used ArcGIS to project the road map into the South America Equal Area Conic projection. With an administrative map, similarly projected, I used the intersect and summarize tools to determine total road length and road density per municipality.

[3] Using IDRISI, I developed a global panel data set of the average annual precipitation rate from 2000 to 2013 by merging $0.25^\circ \times 0.25^\circ$ gridded monthly precipitation data available from the Tropical Rainfall Measuring Mission (Table 1). I then used ArcGIS to project these data into South America Equal Area Conic projection and the zonal statistics tool to obtain average annual precipitation rate (mm/hr) by municipality and year.

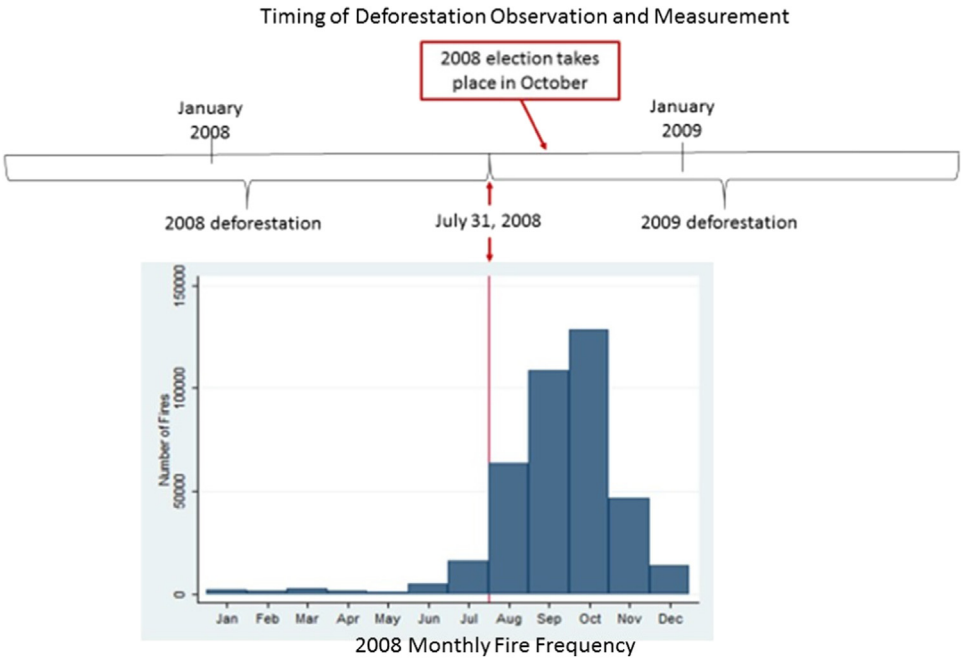

Fig. 3. Monthly fire incidents illustrated alongside the timeline of the deforestation measure and elections.

deforestation monitoring system, since this measure changes over time, and could influence deforestation measures.

High deforestation rates can result in municipality blacklisting by the Ministry of Environment, restricting access to credit, imposing embargoes on local agribusiness, and exacting civil suits on firms purchasing products from embargoed suppliers; I therefore include a control variable for municipalities blacklisted in a given year (Arima et al., 2014; Assunção and Rocha, 2014). I include cumulative protected and indigenous area in a given municipality and year since they have been shown to reduce deforestation rates (Ricketts et al., 2010) and many were established during the 2000s.[4] Since enforcement levels influence deforestation rates, and since monitoring and enforcement are time-variant, I include deforestation-related embargoes by municipality and year to control for environmental enforcement. Agricultural GDP and rural credit are also included as control variables since agricultural production influences deforestation and varies over time. I control for population size and the number of settlement projects in a given municipality in a given year, since population dynamics can influence deforestation. Finally, I control for a mayor's education level by including a dummy variable equal to one when the mayor has completed at least a secondary school education.

Summary statistics for dependent, independent and control variables are presented in Table 2.

4. Results

4.1. Election cycles and deforestation

The primary specification estimates the effect of an incumbent mayor running for re-election on deforestation in election years as well as the two years prior and following elections (Table 3, Online Appendix Table AI). Results show a significant 8–10% increase (s.e. = 0.04) in deforestation in election years. The lags and leads do not demonstrate a significant change in deforestation in the years leading up to, or following, the election year.[5] These results are robust to specifications that include partial (1 & 4) and full (2, 3, 5, 6) sets of controls, specifications omitting lags and leads (4–6), alternate measures of deforestation (Online Appendix Tables AII & AIII), and samples including municipalities with more than 20% forest cover (Online Appendix Table AIV). All specifications include controls for precipitation and the area unmeasured by the satellite

[4] To obtain cumulative protected and indigenous area, I compiled maps of protected area location as well as year of establishment from Brazil's environment ministry (MMA) and used ArcGIS to develop a panel data set of the total amount of protected area (km sq) in each municipality each year.

[5] F-test results show that the sum of lags and leads is not significantly different from zero: $F(1, 614) = 1.77$, Prob $>$ F $= 0.184$. Because incumbents who lose the election do not likely influence deforestation in the following term (i.e. in $t+1$ and $t+2$), I estimate a specification that tests the effect of an incumbent running for re-election and the first three years of the term (thus focusing only on deforestation during the first term). These results show no significant effect of an incumbent running for re-election on deforestation in the three years leading up to the election year. An F-test further shows that the sum of deforestation during the three years prior to the election is not significantly different from zero. Results of these additional analyses are available in Online Appendix Table AV.

Table 2
Summary statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Municipality area (km^2)	615	7601	15282	64	159540
Deforestation increment (km^2)	6068	25.9	73.2	0	1408
Incumbent run, election year (dummy)	6068	0.098	0.297	0	1
Unobserved area (km^2)	6068	65	295	0	4979
Governing coalition affiliation	6068	0.581	0.494	0	1
Total number of embargoes issued	6068	2.27	8.65	0	258
Total number of environmental fines issued	6068	13.0	32.4	0	1109
Cumulative protected area (km^2)	6068	2307	10081	0	160391
Cumulative indigenous area (km^2)	6068	1593	7225	0	91390
Blacklisted municipality (dummy)	6068	0.028	0.165	0	1
Agricultural GDP (1000 Br Reais)	6068	35561	55117	963	829565
Rural credit (1000 Br Reais)	5720	7049	17700	0.50	279000
Number of settlements	6068	0.123	0.870	0	24
Population (in thousands)	6064	33513	103615	1107	1832424
Secondary school completion	6068	0.686	0.464	0	1
Number of agricultural workers (2006)	6068	4208	4016	126	39883
Number of agricultural groups (2006)	6068	34.8	30.5	0	95
Road density (km/km^2)	6068	0.157	0.107	0	0.608
Avg annual precipitation rate (mm/hr)	6068	0.221	0.071	0	0.437
High level of corruption	1133	0.519	0.500	0	1
Corporate contributions (1000 Br Reais)	897	40.6	175	0	3569
Individual contributions (1000 Br Reais)	897	37.8	74.8	0	958
Self contributions (1000 Br Reais)	897	33.7	71.0	0	949

Table 3
Fixed effects model results: deforestation rates in election periods.

DV: Log increment of deforestation	1	2	3	4	5	6
Incumbent runs for mayor	0.080*	0.094**	0.084*	0.088**	0.100**	0.089**
	(0.042)	(0.043)	(0.045)	(0.040)	(0.041)	(0.042)
Incumbent run (t+1)	−0.031	−0.023	−0.023			
	(0.037)	(0.036)	(0.037)			
Incumbent run (t+2)	−0.019	−0.009	−0.005			
	(0.033)	(0.033)	(0.033)			
Incumbent run (t-1)	−0.030	−0.034	−0.029			
	(0.028)	(0.029)	(0.029)			
Incumbent run (t-2)	−0.041	−0.022	−0.016			
	(0.033)	(0.034)	(0.034)			
Full set of controls	N	Y	Y	N	Y	Y
Observations	6068	5717	5621	6068	5717	5621
R-squared	0.480	0.498	0.506	0.480	0.498	0.506
Number of municipalities	615	610	609	615	610	609

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level, as well as controls for annual precipitation and area unobserved in deforestation monitoring. Specifications 2 & 5 include potentially endogenous controls: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. Specifications 3 & 6 include lagged values of the potentially endogenous controls. Because some control variable data are missing in some municipalities in some years, these observations are excluded from the specifications with full sets of control variables. The same results are obtained when restricting Specification 1 to the same sample that is included in Specification 2. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

monitoring system. Specifications with partial controls (1 & 4) omit potentially endogenous variables: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. Specifications 2 and 4 include the current-period values for the potentially endogenous control variables; Specifications 3 and 6 include the lagged values.

With stricter deforestation policy and enforcement in the latter half of the 2000s, it is possible that electoral deforestation cycles are primarily driven by the 2004 elections, and the electoral deforestation effect diminishes with the implementation of stronger government actions to combat deforestation. Results in Table 4 represent the time period from 2006 onwards (omitting the 2004 elections). These results show that incumbent mayors running for re-election in the 2008 and 2012 elections deforest significantly more than mayors who are not running for re-election. In fact, the magnitude of the incumbent effect is even stronger when omitting the 2004 elections. Brazil's electoral deforestation cycle is present even after the implementation of stronger measures to fight deforestation.

Table 4
Fixed effects model results: deforestation rates in 2008 & 2012 election periods.

DV: Log increment of deforestation	1	2	3	4	5	6
Incumbent runs for mayor	0.134**	0.155***	0.137**	0.150***	0.167***	0.146***
	(0.054)	(0.056)	(0.056)	(0.050)	(0.052)	(0.052)
Incumbent run (t+1)	−0.046	−0.040	−0.035			
	(0.047)	(0.047)	(0.046)			
Incumbent run (t+2)	−0.010	−0.001	0.005			
	(0.032)	(0.033)	(0.032)			
Incumbent run (t-1)	−0.025	−0.022	−0.025			
	(0.030)	(0.031)	(0.031)			
Incumbent run (t-2)	−0.013	−0.006	0.003			
	(0.029)	(0.031)	(0.031)			
Full set of controls	N	Y	Y	N	Y	Y
Observations	3641	3515	3497	3641	3515	3497
R-squared	0.332	0.344	0.349	0.332	0.344	0.349
Number of municipalities	615	610	609	615	610	609

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level, as well as controls for annual precipitation and area unobserved in deforestation monitoring. Specifications 2 & 5 include potentially endogenous controls: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. Specifications 3 & 6 include lagged values of the potentially endogenous controls. Because some control variable data are missing in some municipalities in some years, these observations are excluded from the specifications with full sets of control variables. The same results are obtained when restricting Specification 1 to the same sample that is included in Specification 2. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Election-cycle theory implies that only incumbents seeking re-election manipulate resources. However, not all eligible incumbents seek re-election, and there could be important differences between incumbents that choose to run for re-election and those that do not. Balance tests comparing single-term mayors who run for re-election and those that do not (Table 5) suggest that most characteristics are not significantly different among the two groups, except for the number of settlements and the completion of secondary-level education. I also estimate a specification that examines election-year deforestation among incumbents who run for re-election and incumbents who serve a single term, but do not run for a second (Table 6). These results show that election-year deforestation rates increase significantly among incumbents who run for re-election, but not among mayors who serve a single term and do not run for re-election. If the number of settlements or level of education simultaneously influences whether or not an incumbent runs for re-election and deforestation rates, then we would expect that specifications controlling for these variables (Specification 2) would yield different results than specifications that do not control for these differences, but they do not. Consistent with election-cycle theory, these results support the idea that incumbents seeking re-election have an incentive to manipulate resources to improve their popularity among voters. Eligible incumbents who do not seek re-election do not have such incentives, and do not appear to distort forest resources in election years.

4.2. Enforcement, agricultural activity and agricultural interests

If relaxed environmental enforcement were to lead to increased deforestation in election years, then there should be less enforcement in election periods. However, significantly more embargoes are issued in election years; approximately two more embargoes are issued to firms in the year an incumbent mayor runs for re-election (Table 7). Likewise, between two and three more environmental fines are issued in a given municipality when an incumbent mayor runs for re-election, this effect is also significant (Table 8). This means that environmental enforcement increases in election years, rather than decreasing, as expected.[6] That the number of embargoes and environmental fines increases in election years suggests that increased deforestation in election years may generate an increase in enforcement activity.

Enforcement activity is likely to be unpopular among voters, and reflect poorly on local politicians, thus we would expect candidates to try to reduce environmental enforcement in election years. However, it is possible that environmental enforcement is not subject to this form of political manipulation. Environmental enforcement is implemented by national-level actors; local politicians may have little power over the issuance of embargoes and fines. The increase in environmental enforcement in years of greater deforestation suggests this may be the case. In addition, the issuance of embargoes and fines does not necessarily mean that penalties are imposed. It can take years for violations to be legally processed, many cases are dismissed or allowed reparations in place of fines, and most environmental fines go uncollected - some report as little as 2% of environmental fines issued are actually paid (de Souza, 2006; Banerjee et al., 2009; Brito and Barreto, 2011). Increases in enforcement activity in election years may have no real consequences for voters, and subsequently may not influence voting

[6] Note that daily monitoring and enforcement of deforestation activity occurs using the Real-time System for Detection of Deforestation (DETER) while annual deforestation measures used in this analysis come from PRODES.

Table 5
Test for differences in means between election-eligible incumbents who do not run versus eligible incumbents who do run.

Variable	Incumbent runs for re-election (N = 897)		Incumbent does not run for re-election (N = 253)		Std Diff	p-value
	Mean	Std Dev	Mean	Std Dev		
Avg annual precipitation (mm/hr)	0.23	0.06	0.23	0.06	0.06	0.37
Forested area (km^2)	5327	14046	4758	12761	0.04	0.56
Agricultural GDP (1000 Br Reais)	44847	76746	50532	64245	−0.08	0.28
Rural credit (1000 Br Reais)	10097	10462	28960	22168	−0.01	0.85
Number of embargoes	4.05	13.28	3.9	9.13	0.01	0.87
Number of fines issued	12.79	31.81	10.23	22.36	0.09	0.23
Number of agricultural workers	4141	4047	4185	3491	−0.01	0.87
Number of agricultural groups	35.14	30.41	36.42	33.26	−0.04	0.56
Cumulative protected area (km^2)	2413	10106	3123	14399	−0.06	0.37
Cumulative indigenous area (km^2)	1256	6763	1079	6789	0.03	0.71
Number of settlements	0.04	0.24	0.01	0.11	0.17	0.04
Population (in thousands)	31734	90016	33889	133190	−0.02	0.76
Secondary school completion	0.71	0.45	0.64	0.48	0.16	0.02
Road density (km/km^2)	0.16	0.16	0.11	0.11	−0.08	0.27

Table 6
Deforestation rates in election periods differentiating the effect of election-eligible incumbents who do not run versus eligible incumbents who do run.

DV: Log increment of deforestation	1	2	3
Incumbent runs for mayor	0.076*	0.096**	0.076*
	(0.042)	(0.043)	(0.045)
Incumbent does not run	−0.054	−0.019	−0.054
	(0.073)	(0.076)	(0.078)
Full set of controls	N	Y	Y
Observations	6068	5717	5621
R-squared	0.480	0.498	0.506
Number of municipalities	615	610	609

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level, as well as controls for annual precipitation and area unobserved in deforestation monitoring. Specification 2 includes potentially endogenous controls: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. Specification 3 includes lagged values of the potentially endogenous controls. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 7
Electoral deforestation cycle driver effects: embargoes and environmental fines.

DV: Enforcement	Embargoes (total)		Environmental fines (total)	
	1	2	1	2
Incumbent runs for mayor	2.342**	2.274**	2.628**	2.330*
	(0.933)	(-0.935)	(1.182)	(1.194)
Incumbent run (t+1)	0.991	1.007	−1.074	−1.305
	(0.784)	(-0.788)	(1.200)	(1.272)
Incumbent run (t+2)	0.058	−0.013	−0.436	−0.695
	(0.297)	(-0.315)	(0.935)	(0.972)
Incumbent run (t-1)	−0.417	−0.384	−0.122	−0.331
	(0.479)	(-0.491)	(1.167)	(1.257)
Incumbent run (t-2)	−0.287	−0.295	0.159	0.004
	(0.320)	(-0.337)	(0.741)	(0.803)
Full set of controls	N	Y	N	Y
Observations	3641	3502	6068	5717
R-squared	0.083	0.115	0.038	0.053
Number of municipalities	615	610	615	610

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level, as well as controls for annual precipitation and area unobserved in deforestation monitoring. Specification 2 includes potentially endogenous controls: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 8
Electoral deforestation cycle driver effects: agricultural GDP and agricultural credit.

DV: Agricultural activity	Ag GDP (log)		Ag Credit (log)	
	1	2	1	2
Incumbent runs for mayor	0.009	0.012	−0.061	−0.062
	(0.017)	(0.017)	(0.057)	(0.057)
Incumbent run (t+1)	−0.007	−0.004	−0.052	−0.049
	(0.016)	(0.015)	(0.055)	(0.055)
Incumbent run (t+2)	−0.005	−0.004	−0.130***	−0.128***
	(0.018)	(0.017)	(0.050)	(0.050)
Incumbent run (t-1)	−0.003	0.006	−0.073	−0.071
	(0.014)	(0.014)	(0.046)	(0.046)
Incumbent run (t-2)	−0.013	−0.005	−0.101**	−0.096**
	(0.016)	(0.015)	(0.048)	(0.048)
Full set of controls	N	Y	N	Y
Observations	6068	5717	5720	5717
R-squared	0.653	0.677	0.369	0.370
Number of municipalities	615	610	610	610

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level, as well as controls for annual precipitation and area unobserved in deforestation monitoring. Specification 2 includes potentially endogenous controls: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 9
Electoral deforestation cycle driver effects: agricultural credit cycles differentiated between the time period before and after the 2008 election and agricultural credit restrictions.

DV: Log agricultural credit	Pre-2008 election		Post-2008 election	
	1	2	1	2
Incumbent runs for mayor	0.025	−0.004	−0.066	−0.070
	(0.013)	(0.127)	(0.078)	(0.079)
Incumbent run (t+1)	0.090	0.071	−0.092	−0.095
	(0.130)	(0.130)	(0.072)	(0.073)
Incumbent run (t+2)	−0.004	−0.026	−0.150***	−0.153***
	(0.141)	(0.142)	(0.048)	(0.048)
Incumbent run (t-1)	0.009	−0.014	−0.048	−0.046
	(0.133)	(0.133)	(0.053)	(0.053)
Incumbent run (t-2)	−0.018	−0.033	−0.084	−0.083
	(0.072)	(0.072)	(0.055)	(0.055)
Full set of controls	N	Y	N	Y
Observations	2798	2796	3503	3502
R-squared	0.433	0.437	0.154	0.155
Number of municipalities	600	600	607	607

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level, as well as controls for annual precipitation and area unobserved in deforestation monitoring. Specification 2 includes potentially endogenous controls: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. ***p < 0.01, **p < 0.05, *p < 0.1.

behavior.[7]

Results testing for the presence of election cycles in agricultural variables are presented in Table 8. Agricultural GDP does not significantly fluctuate with election periods. Agricultural credit is negative in all specifications in all years; up to 13% lower, and significantly so (s.e. = 0.05) in the second lead and lag when mayors are re-election eligible, but is not significantly different in the time period surrounding elections. That mid-term agricultural credit allocation is negative and significant among re-election eligible mayors, but is not significantly different in election years suggests a relationship between agricultural credit and electoral deforestation cycles.

Since 2008, approval of rural credit applications in the Amazon has been conditional upon proof of the applicant's

[7] I estimated the effect of the number of embargoes and fines issued on the mayor's winning (or losing) vote margin and the probability of a mayor winning re-election. These estimations did not show any significant effect of enforcement on the probability of winning or the share of votes received.

Table 10
Deforestation and agricultural credit post-2008.

DV: Log agricultural credit	1	2
Log increment of deforestation	−0.005	−0.015
	(0.026)	(0.027)
Log increment of deforestation (t+1)	−0.046	−0.056*
	(0.032)	(0.032)
Log increment of deforestation (t+2)	−0.079**	−0.083**
	(0.034)	(0.034)
Log increment of deforestation (t-1)	−0.003	−0.006
	(0.027)	(0.027)
Log increment of deforestation (t-2)	−0.008	−0.007
	(0.023)	(0.024)
Full set of controls	N	Y
Observations	2958	2933
R-squared	0.143	0.148
Number of municipalities	608	607

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level, as well as controls for annual precipitation and area unobserved in deforestation monitoring. Specification 2 includes potentially endogenous controls: agricultural GDP, blacklisting, protected and indigenous areas, population, number of settlements, and mayor education. The time period includes years 2006 and 2007 to account for deforestation in the two years prior to 2008, but results are similar when including only years 2008–2012. ***p < 0.01, **p < 0.05, *p < 0.1.

environmental compliance (Assunção et al. 2013a,b). Establishments with embargoes imposed due to deforestation or with environmental regulation violations are ineligible to receive government-subsidized rural credit. Increased deforestation in election years, and the resulting environmental penalties could ultimately preclude agricultural credit acquisition in subsequent time periods. Table 9 shows election cycles in agricultural credit pre and post 2008, when rural credit is restricted to environmentally-compliant establishments. These results show that agricultural credit is only significantly affected after 2008, and only in the second year after an election. In addition, results from specifications estimating the effect of deforestation and its lags and leads on agricultural credit show that increased deforestation significantly reduces agricultural credit two years later (Table 10).

Like environmental enforcement, agricultural credit may be affected by electoral deforestation cycles, rather than affecting electoral deforestation cycles. The increase in deforestation and deforestation-related penalties in election years could prevent agricultural credit allotments in later years.[8] This kind of a relationship between election-year deforestation and a subsequent decrease in agricultural credit is characteristic of election-cycle resource manipulation: manipulating forest resources in election years to boost popularity induces costs (reductions in agricultural credit) that are not realized until after the election, when the incumbent can no longer be “punished” by voters.

To further explore the relationship between environmental enforcement and agricultural credit, I estimate municipality-fixed-effects specifications that examine the effect of the number of embargoes and the number of fines issued in a given year, and the prior two years, on the amount of agricultural credit issued (Online Appendix Table AVI). While the results do not show a significant relationship between environmental enforcement and agricultural credit, the sign of the coefficient suggests that, consistent with results shown in Tables 9 and 10, agricultural credit has a negative relationship with embargoes issued two years prior. The number of fines has a negative relationship with agricultural credit in the two time periods following their issuance.

Online Appendix Table AVII shows there is not a significant marginal effect of road density on deforestation in municipalities with an incumbent mayor running for re-election, compared with municipalities without an incumbent mayor running for re-election. While road density itself does not significantly influence election-period deforestation, it is possible that changes in road density could.

Online Appendix Table AVIII shows results from specifications that account for the size of the agricultural labor force (as a proxy for constituency composition) and the number of organized agricultural groups (a proxy for agricultural interest groups). Neither agricultural labor force size nor organized agricultural group presence significantly influences deforestation rates in election years. Incumbent mayors do not appear to manipulate forest resource allocation in election periods to appeal to agricultural constituencies or interest groups.

4.3. Political alignment

Results presented in Table 11 show that government coalition affiliation has a negative effect on deforestation in

[8] That the second prior time period is affected could be a function of a delay in reporting imposition of an embargo and also the time period between when agricultural credit applications are drafted, submitted and approved.

Table 11
Effect of mayor affiliation with the governing coalition on electoral deforestation cycles.

DV: Increment of deforestation (log)	1	2
Incumbent run	0.140**	0.155***
	(0.055)	(0.056)
Incumbent run (t+1)	−0.006	0.004
	(0.045)	(0.045)
Incumbent run (t+2)	−0.018	−0.0001
	(0.040)	(0.040)
Incumbent run (t-1)	−0.012	−0.007
	(0.041)	(0.042)
Incumbent run (t-2)	−0.020	0.019
	(0.048)	(0.049)
Governing coalition	0.002	0.006
	(0.024)	(0.024)
Incumbent run*govt coal	−0.109*	−0.110
	(0.066)	(0.068)
Incumbent run*govt coal (t+1)	−0.044	−0.049
	(0.055)	(0.055)
Incumbent run*govt coal (t+2)	−0.006	−0.023
	(0.042)	(0.043)
Incumbent run*govt coal (t-1)	−0.029	−0.041
	(0.047)	(0.049)
Incumbent run*govt coal (t-2)	−0.034	−0.067
	(0.053)	(0.053)
Full set of controls	N	Y
Observations	6067	5716
R-squared	0.480	0.499
Number of municipalities	615	610

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level, as well as controls for annual precipitation and area unobserved in deforestation monitoring. Specification 2 includes potentially endogenous controls: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. ***p < 0.01, **p < 0.05, *p < 0.1.

election years (coeff. = 0.11 s.e. = 0.07), this effect is significant in the specification that excludes potentially endogenous control variables. It is possible that political alignment between national and local-level politicians may deter deforestation if affiliated mayors receive extra resources to support them in election periods, and mayors could appeal to voters through other means that do not increase deforestation. Table 12 shows that government coalition-affiliated mayors running for re-election receive 3% more federal transfers in election years than non-affiliated mayors and 2% more federal transfers in the years following the election.[9] Results in Table 12 also show that more federal transfers translate to less deforestation, but this effect is not specific to election years, and is only significant in the specification that does not include a full set of control variables. In addition to increased federal transfers, government coalition members could receive other forms of political support in election years from their national counterparts that obviates using deforestation as a means to win over voters.

4.4. Corruption

Using the subset of randomly-selected municipalities that received audits, I estimated the effect of at least one documented "serious" corruption offense on electoral deforestation cycles. When a corrupt politician runs for re-election there is a 45–60% increase (s.e. = 0.3) in deforestation compared with municipalities without a corrupt mayor running for re-election; this effect is significant in specifications that omit endogenous control variables (Table 13). Because the sub-sample of municipalities with corruption data is small, I also estimate the effect of corruption using municipalities with any amount of forest cover greater than zero in 2000. The larger sample of municipalities shows a similar effect that is statistically significant in both specifications. While the sample size is small, these results suggest that election year deforestation is positively and significantly correlated with corruption[10].

[9] Brollo et al. (2013) find significantly more federal transfers are issued in the latter half of the mayor's term rather than the first half. Since federal-level elections occur two years after municipal-level elections, the government may continue to financially support politically-aligned municipalities in exchange for political support in the upcoming election.

[10] Some municipalities (129) were audited more than once. Of 129 municipalities audited more than once 75% were found to be corrupt in at least one term; in other words 25% of municipalities were never corrupt. Eighteen percent of municipalities were corrupt in all terms and 57% were corrupt in some terms and not in others. Municipalities do not appear to be consistently corrupt or not over time.

Table 12
Electoral cycles in federal transfers and effects on deforestation.

DV: Federal Transfers		DV: Increment of deforestation (log)	1	2
Incumbent run	−0.012	Incumbent run	−0.289	−0.331
	(0.014)		(0.638)	(0.803)
Incumbent run (t+1)	0.006	Incumbent run (t+1)	0.197	−0.399
	(0.010)		(0.810)	(0.596)
Incumbent run (t+2)	−0.014	Incumbent run (t+2)	0.131	0.036
	(0.012)		(0.641)	(0.599)
Incumbent run (t-1)	−0.004	Incumbent run (t-1)	0.097	−0.809
	(0.013)		(0.783)	(0.600)
Incumbent run (t-2)	−0.018	Incumbent run (t-2)	0.361	0.422
	(0.011)		(0.664)	(0.525)
Governing coalition	0.008	Federal transfers (log)	−0.125*	−0.022
	(0.007)		(0.075)	(0.079)
Incumbent run*	0.033**	Incumbent run*	0.018	0.029
govt coal	(0.016)	federal transfer	(0.040)	(0.051)
Incumbent run*	0.023*	Incumbent run*	−0.005	0.023
govt coal (t+1)	(0.013)	federal transfer (t+1)	(0.052)	(0.038)
Incumbent run*	0.024*	Incumbent run*	−0.009	−0.005
govt coal (t+2)	(0.013)	federal transfer (t+2)	(0.041)	(0.038)
Incumbent run*	0.008	Incumbent run*	−0.009	0.050
govt coal (t-1)	(0.016)	federal transfer (t-1)	(0.049)	(0.038)
Incumbent run*	0.018	Incumbent run*	−0.022	−0.029
govt coal (t-2)	(0.013)	federal transfer (t-2)	(0.041)	(0.032)
		Full set of controls	N	Y
Observations	5677	Observations	4223	3985
R-squared	0.893	R-squared	0.456	0.518
Number of municipalities	615	Number of municipalities	599	590

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level. Specifications testing for cycles in federal transfers include controls for mayor education and population. Both specifications testing for deforestation cycles include controls for annual precipitation and area unobserved in deforestation monitoring. Specification 2 includes potentially endogenous controls: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. ***p < 0.01, **p < 0.05, *p < 0.1.

4.5. Campaign contributions

Results presented in Table 14 demonstrate the relationship between the amount of campaign contributions and deforestation rates in election periods. The coefficient on the interaction term between the incumbent running for re-election dummy variable and the log value of campaign contributions shows that there is no significant relationship between corporate or individual campaign contributions and deforestation in election years, but there is a positive, significant relationship between self-funded campaign contributions and deforestation in election years. Municipalities with incumbent mayors running for re-election who have zero self-funded campaign contributions do not have significantly different deforestation rates than those municipalities without an incumbent mayor running for re-election. These results are consistent when estimating the effect of self-funding as a binary variable (Online Appendix Table AIX). The negative coefficient on the incumbent run variable suggests incumbent mayors with zero self-funded campaign contributions actually deforest less, yet for each 1% increase in self-funded campaign contributions, there is a 0.017% increase in deforestation. In other words, a municipality with a mayor with twice the amount of self-funded campaign contributions than another mayor will experience 1.7% more deforestation in the election year.

4.6. Deforestation and voting behavior

There is not a significant relationship between deforestation and the number of votes received or the probability of a mayor winning re-election (Table 15). If anything, OLS regression specifications show that more deforestation in the election year decreases the mayor's vote margin, but again, this effect is not significant. In both models, I estimate specifications (2 & 4) that include the log value of self-funded campaign contributions because more deforestation may mean fewer votes, but more funding for campaign contributions could outweigh this effect. Deforestation has a negative, but insignificant, effect on the vote margin and the probability of winning an election, but the amount of self-funded campaign contributions has a positive effect, and this effect is significant at the $p < 10\%$ level in the logit model (4). These results are robust to a binary measure of self-funding (Online Appendix Table AX) and suggest that if increased deforestation decreases the chances of winning an election, that this effect could be offset with additional campaign funding.

Table 13
Corruption and electoral deforestation cycles.

DV: Increment of deforestation (log)	> 10% forest cover in 2000		> 0 forest cover in 2000	
	1	2	1	2
Incumbent run	−0.337**	−0.339**	−0.351**	−0.361**
	(0.130)	(0.155)	(0.143)	(0.158)
Incumbent run (t+1)	−0.366**	−0.265*	−0.357**	−0.275**
	(0.150)	(0.139)	(0.152)	(0.136)
Incumbent run (t+2)	−0.189	−0.093	−0.176	−0.078
	(0.157)	(0.150)	(0.160)	(0.146)
Incumbent run (t-1)	−0.268*	−0.355***	−0.225	−0.288**
	(0.139)	(0.131)	(0.141)	(0.127)
Incumbent run (t-2)	−0.217	−0.187	−0.150	−0.123
	(0.185)	(0.190)	(0.164)	(0.167)
High corruption	−0.026	−0.077	−0.026	−0.039
	(0.110)	(0.127)	(0.104)	(0.117)
Incumbent run*high corruption	0.605**	0.456	0.659**	0.523*
	(0.305)	(0.298)	(0.303)	(0.289)
Incumbent run*high corr (t+1)	0.440	0.235	0.372	0.188
	(0.315)	(0.315)	(0.311)	(0.304)
Incumbent run*high corr (t+2)	0.141	−0.098	0.102	−0.109
	(0.293)	(0.290)	(0.302)	(0.295)
Incumbent run*high corr (t-1)	0.187	0.089	0.183	0.057
	(0.278)	(0.264)	(0.275)	(0.262)
Incumbent run*high corr (t-2)	0.257	0.226	0.088	0.060
	(0.201)	(0.186)	(0.172)	(0.163)
Full set of controls	N	Y	N	Y
Observations	468	436	528	496
R-squared	0.478	0.528	0.425	0.470
Number of municipalities	106	105	120	119

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level, as well as controls for annual precipitation and area unobserved in deforestation monitoring. Specification 2 includes potentially endogenous controls: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. ***p < 0.01, **p < 0.05, *p < 0.1.

5. Discussion

5.1. Election cycles and deforestation

Although elections serve to discourage opportunistic behavior (Besley and Case, 1995), elections create additional incentives to engage in rent-seeking activity (Smith et al., 2003; Burgess et al., 2015). My results reinforce these findings; local elections in Brazil create incentives for mayors to engage in deforestation-inducing activity. Inefficient allocation of public resources arises in democratic processes because of electoral incentives; young democracies and weak institutions exacerbate this effect (Shleifer and Vishny, 1993; Smith et al., 2003; Shi and Svensson, 2006).

Politicians have incentives to distort public goods allocation in an election cycle when voters are generally unable to detect election cycles, since distortions are misconstrued as competence. In the case of deforestation in Brazil, this may be particularly relevant because 1) Brazil is a relatively new democracy, and only recently have mayors been able to run for a second term, therefore voters may not be as privy to election cycles and 2) fluctuations in deforestation are not likely readily observed, so election-period distortions may be hidden in deforestation rather than in other public goods allocation.

5.2. Corruption and election cycles

Results suggest electoral deforestation cycles may be explained by rent-seeking behavior, which supports previous findings that election cycles are strongest in countries with weak institutions (Shi and Svensson, 2006). Countries with weak institutions are less able to punish resource misallocation, increasing a corrupt politician's ability to extract private rents and his/her incentives to remain in office (Shleifer and Vishny, 1993; Shi and Svensson, 2006). Higher private benefits provide even more incentives for a corrupt politician to engage in behavior that induces election cycles, and more resources to do so, leading to more severe electoral manipulation (Robinson et al., 2006).

Corrupt politicians may substitute one form of corruption for another, shifting rent-seeking activity to less visible forms, such as forests (Shleifer and Vishny, 1993; Burgess et al., 2011). Cisneros et al. (2013) found that following a random public

Table 14
Corporate, individual and self-funded campaign contribution value and electoral deforestation cycles.

DV: Log increment deforestation	CORP (log total value)		IND (log total value)		SELF (log total value)	
	1	2	1	2	1	2
Incumbent run	0.063	0.073	0.110*	0.125*	−0.033	−0.031
	(0.053)	(0.054)	(0.062)	(0.064)	(0.055)	(0.058)
Incumbent run (t+1)	−0.014	−0.007	0.022	0.031	−0.043	−0.035
	(0.045)	(0.045)	(0.049)	(0.049)	(0.055)	(0.055)
Incumbent run (t+2)	−0.035	−0.032	−0.024	−0.026	−0.042	−0.044
	(0.039)	(0.039)	(0.046)	(0.048)	(0.047)	(0.049)
Incumbent run (t-1)	−0.056	−0.070*	−0.029	−0.023	−0.050	−0.056
	(0.037)	(0.038)	(0.047)	(0.049)	(0.044)	(0.046)
Incumbent run (t-2)	−0.038	−0.010	−0.075	−0.031	−0.047	−0.048
	(0.044)	(0.045)	(0.057)	(0.058)	(0.053)	(0.056)
Incumbent run*val cont	0.004	0.005	−0.005	−0.005	0.017***	0.018***
	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)	(0.007)
Incumbent run*val cont (t+1)	−0.004	−0.003	−0.008	−0.008	0.002	0.002
	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
Incumbent run*val cont (t+2)	0.004	0.005	0.001	0.003	0.003	0.005
	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Incumbent run*val cont (t-1)	0.005	0.007	−0.0001	−0.001	0.003	0.003
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
Incumbent run*val cont (t-2)	−0.0002	−0.002	0.005	0.001	0.001	0.004
	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
Full set of controls	N	Y	N	Y	N	Y
Observations	6068	5717	6068	5717	6068	5717
R-squared	0.480	0.499	0.480	0.499	0.481	0.499
Number of municipalities	615	610	615	610	615	610

All specifications include state-year and municipality fixed effects and clustered standard errors (in parentheses) at the municipal-level, as well as controls for annual precipitation and area unobserved in deforestation monitoring. Specification 2 includes potentially endogenous controls: agricultural GDP, agricultural credit, blacklisting, number of embargoes, protected and indigenous areas, population, number of settlements, and mayor education. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 15
Deforestation and voting behavior.

	DV: Vote margin		DV: Wins election	
	1	2	3	4
Normalized deforestation increment	−0.004	−0.004	0.014	−0.004
	(0.012)	(0.012)	(0.099)	(0.100)
Value (log) of self-funded campaign contributions		0.001		0.031*
		(0.002)		(0.016)
Observations	848	848	893	893
R-squared/Pseudo R-squared	0.055	0.055	0.041	0.044

All specifications include state-year fixed effects and controls for mayor education, the presence of a local newspaper and the presence of a radio station. ***p < 0.01, **p < 0.05, *p < 0.1.

fiscal audit, municipalities engaged in significantly more deforestation; attributing this effect to mayors shifting illegal, corrupt behavior to activities that are difficult to monitor through public audits. When political manipulation is driven by rent-seeking behavior, forest resources may be particularly vulnerable. Compared with other public goods misallocation, forest exploitation is difficult to detect (Kolstad and Søreide, 2009; Burgess et al., 2011; Cisneros et al., 2013). For this reason, corrupt mayors may specifically engage in deforestation in election periods because it is easy to conceal, and difficult to attribute to a particular actor.

5.3. Importance of campaign finance in Brazil

Results collectively point to the idea that electoral deforestation cycles are more about raising money for campaigns than about appealing to the masses by promoting agricultural activity. That self-funded campaign contributions are positively and significantly linked to electoral deforestation cycles, while external contributions are not, is interesting given Brazil's

political campaigns are infamously tied to corporate entities.[11] However, many donors contribute "off the books" (Gingerich, 2014), and since there tend to be close relationships between donors and politicians (i.e. are often friends and family, Samuels, 2001b), it is feasible that politicians claim such contributions as their own. In addition, while there are limits to the quantities individuals and corporate entities can contribute, there are no limits to the amount that candidates can contribute themselves (Samuels, 2001a). When reporting campaign contributions, candidates may claim contributions from individuals and corporations as their own so that those corporations and individuals remain within contribution limits.

Corruption and campaign finance are tightly linked. Gingerich (2014) found that corrupt politicians were more likely to receive "off the books" funding, which was often used to bribe local powerful, authoritative elites to serve as vote brokers and build electoral support in their communities. Given the role of corruption in electoral deforestation cycles, perhaps politicians allow greater deforestation in exchange for bribes, which is ultimately used to finance campaigns under the guise of "self-funded" contributions.

It is also possible that politicians are cutting down trees themselves. In an interview with NPR's Lourdes Garcia-Navarro, Brazilian politician Herminio Coelho said, "Unfortunately, all our politicians … make their money from logging, from cattle ranching. They all own land (Garcia-Navarro, 2015)." Politicians who run firms responsible for deforestation may increase firm activity, and consequently deforestation rates, in election years to earn money for their campaigns. Brazil's campaign finance, dubious politician-firm relations and corruption are notoriously intertwined (Gingerich, 2014; Brollo and Troiano, 2016). This political climate of corruption, patronage and bribery, combined with re-election incentives and the ability to clandestinely gain from forest resources creates perfect conditions for electoral deforestation cycles.

6. Conclusion

Elections create incentives for politicians to distort public goods provision, leading to undesirable outcomes such as increased deforestation. This is not to say that democratic elections do more harm than good, but there may be important implications for centralization versus decentralization of resource governance. Local levels of governance can render natural resources more susceptible to political manipulation (Bardhan and Mookherjee, 2000). Resource decentralization leads to local elite capture, and with more discretionary power over forests, local politicians have greater incentives and ability to exploit forest resources (Jain, 2001; Kolstad and Søreide, 2009). These effects are further exacerbated by weak institutions and corruption. Centralized forest governance reduces local politicians' ability to manipulate resource allocation. Since Brazil's environmental policy and enforcement is currently administered by a central agency, electoral deforestation cycles in Brazil could be worse under a scenario where forest governance is decentralized.

Despite Brazil's relatively centralized forest governance, it is clear that Brazil's politicians have the power to misallocate forest resources. While forest resources should not be further decentralized, lest rendering them even more vulnerable to political manipulation, politicians should bear responsibility for deforestation in their municipalities. If political power is contingent upon good forest governance, then politicians may be more inclined to keep forests intact. Existing mechanisms designed to deter deforestation are insufficient. Environmental enforcement will accomplish little if violators never have to pay fines, and agricultural credit restrictions will only be effective on individuals who cannot access other lines of credit (from private banks). Politically powerful, wealthy individuals will need a different set of penalties to deter them from deforestation. Holding politicians directly accountable for deforestation in their municipalities, and allowing politicians to remain in public office only when they demonstrate satisfactory environmental performance, could provide an effective means of reducing deforestation.

Prior work indicates that electoral cycles and corruption are more, and more often, present in new democracies with weak institutions and little capacity to punish resource misallocation (Shleifer and Vishny, 1993; Jain, 2001; Shi and Svensson, 2006). Although Brazil is a relatively new democracy, its institutional performance is quite good. For instance, Brazil is well above average for five of six of the Worldwide Governance Indicators and is ranked lower in corruption indices than other forest-rich countries like Peru and Indonesia (TI, 2013; WGI, 2013). Given electoral deforestation cycles have been observed in Brazil, a country with relatively strong institutions, this could suggest that natural resources in countries with weaker institutions may be even more vulnerable to political manipulation.

Natural resources are subject to political processes. Political economy theory predicts that politicians manipulate public goods when faced with electoral incentives, however little research, excepting Burgess et al. (2011) applies such theory to natural resources. Here, I show that local politics indeed influence natural resource allocation; specifically, mayors use deforestation-inducing practices as a way to garner votes for upcoming elections. While this work finds that the world's most cherished forests are subject to electoral deforestation cycles, this phenomenon is likely not unique to the Brazilian Amazon. Nor is this phenomenon limited to forest resources. Electoral incentives shape resource allocation decisions; these choices affect all forms of natural resources and, more broadly, all types of public goods. Understanding how political decision-making influences natural resource exploitation provides important contributions to both political economy theory and conservation policy.

[11] In 2015, Brazil's Supreme Court banned corporate donations to political campaigns amid the Petrobras corruption scandal.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jeem.2018.01.008.

References

Akhmedov, Akhmed, Zhuravskaya, Ekaterina, 2004. Opportunistic political cycles: test in a young democracy setting. Q. J. Econ. 119 (4), 1301–1338.

Alston, Lee J., Libecap, Gary D., Mueller, Bernardo, 2000. Land reform policies, the sources of violent conflict, and implications for deforestation in the Brazilian Amazon. J. Environ. Econ. Manag. 39 (2), 162–188.

Agrawal, Arun, 2007. Forests, governance, and sustainability: common property theory and its contributions. Int. J. Commons 1 (1), 111–136.

Andersson, Krister P., Gibson, Clark C., 2007. Decentralized governance and environmental change: local institutional moderation of deforestation in Bolivia. J. Pol. Anal. Manag. 26 (1), 99–123.

Andersson, Krister P., Gibson, Clark C., Lehoucq, Fabrice E., 2004. The politics of decentralized natural resource governance. Political Sci. Polit. 37 (3), 421–426.

Andersson, Krister P., Gibson, Clark C., Lehoucq, Fabrice E., 2006. Municipal politics and forest governance: comparative analysis of decentralization in Bolivia and Guatemala. World Dev. 34 (3), 576–595.

Araujo, Claudio, Catherine, Araujo Bonjean, Jean-Louis, Combes, Combes Motel, Pascale, Reis, Eustaquio J., 2009. Property rights and deforestation in the Brazilian Amazon. Ecol. Econ. 68 (8–9), 2461–2468.

Arima, Eugenio Y., Barreto, Paulo, Araújo, Elis, Soares-Filho, Britaldo, 2014. Public policies can reduce tropical deforestation: lessons and challenges from Brazil. Land Use Pol. 41 (November), 465–473.

Assunção, Juliano, Gandour, Clarissa, Rocha, Romero, 2013a. DETERring Deforestation in the Brazilian Amazon: Environmental Monitoring and Law Enforcement. Climate Policy Initiative Working Paper, Rio de Janeiro, Brazil.

Assunção, Juliano, Gandour, Clarissa, Rocha, Romero, Rocha, Rudi, 2013b. Does Credit Affect Deforestation? Evidence from a Rural Credit Policy in the Brazilian Amazon. Climate Policy Initiative Working Paper, Rio de Janeiro, Brazil.

Assunção, Juliano, Rocha, Romero, 2014. Getting Greener by Going Black: the Priority Municipalities in Brazil. Climate Policy Initiative Working Paper, Rio de Janeiro, Brazil.

Bardhan, Pranab, Mookherjee, Dilip, 2000. Capture and governance at local and national levels. Am. Econ. Rev. 90 (2), 135–139.

Balakrishnan, Angela, 2008. Brazilian government faces criminal charges over Amazon deforestation. The Guardian. September 30 http://www.theguardian.com/environment/2008/sep/30/forests.brazil.

Banerjee, Onil, Macpherson, Alexander, Alavalapati, Janaki, 2009. Toward a policy of sustainable forest management in Brazil. J. Environ. Dev. 18 (2), 130–153.

Baskaran, Thushyanthan, Min, Brian, Uppal, Yogesh, 2015. Election cycles and electricity provision: evidence from a quasi-experiment with Indian special elections. J. Publ. Econ. 126, 64–73.

Besley, Timothy, Case, Anne, 1995. Does electoral accountability affect economic policy choices? Evidence from gubernatorial term limits. Q. J. Econ. 110 (3), 769–798. Oxford University Press.

Binswanger, Hans P., 1991. Brazilian policies that encourage deforestation in the Amazon. World Dev. 19 (7), 821–829.

Brito, Brenda, Barreto, Paulo, 2011. Enforcement against illegal logging in the Brazilian Amazon. In: Lee Paddock, D.Z., Qun, Du, Kotzé, Louis J., Markell, David L., Markowitz, Kenneth J. (Eds.), Compliance and Enforcement in Environmental Law: Toward More Effective Implementation, Edward Elgar Publishing, Cheltenham, UK, pp. 712.

Brollo, Fernanda, Nannicini, Tommaso, 2012. Tying your enemy's hands in close races: the politics of federal transfers in Brazil. Am. Polit. Sci. Rev. 106 (04), 742–761.

Brollo, Fernanda, Nannicini, Tommaso, Perotti, Roberto, Tabellini, Guido, 2013. The political resource curse. Am. Econ. Rev. 103 (5), 1759–1796.

Brollo, Fernanda, Troiano, Ugo, 2016. What happens when a woman wins an election? Evidence from close races in Brazil. J. Dev. Econ. 122, 28–45.

Bugarin, Mauricio, Ubrig, Ricardo, 2012. Partisan Voluntary Transfers in a Fiscal Federation: New Evidence from Brazil Working Paper. http://bugarinmauricio.com/current-research/.

Burgess, Robin, Matthew, Hansen, Olken, Benjamin A., Potapov, Peter, Sieber, Stefanie, 2011. The Political Economy of Deforestation in the Tropics NBER Working Paper No. 17417. http://www.nber.org/papers/w17417.pdf.

Burgess, Robin, Jedwab, Remi, Miguel, Edward, Morjaria, Gerard, Ameet, Padró i Miquel, 2015. The value of democracy: Evidence from road building in Kenya. Am. Econ. Rev. 105 (6), 1817–1851.

Chomitz, Kenneth M., Gray, David A., 1996. Roads, land use, and deforestation: a spatial model applied to Belize. World Bank Econ. Rev. 10 (3), 487–512.

Cisneros, Elias, Hargrave, Jorge, Kis-Katos, Krisztina, 2013. Unintended Consequences of Anti-corruption Strategies: Public Fiscal Audits and Deforestation in the Brazilian Amazon Working Paper. http://www.bioecon-network.org/pages/15th_2013/CISNEROS.pdf.

Cole, Shawn, 2009. Fixing market failures or fixing elections? Agricultural credit in India. Am. Econ. J. Appl. Econ. 1 (1), 219–250.

de Souza, Oswaldo, B., 2006. Fiscalização aumenta presença na Amazônia, mas impunidade para os crimes ambientais continua Noticias Socioambientais November 21, 2006. Instituto Socioambiental Retrieved from https://site-antigo.socioambiental.org/nsa/detalhe?id=2369.

Drazen, Allan, 2001. The Political Business Cycle after 25 Years NBER Macroeconomics Annual 2000 15. 75–138.

Drazen, Allan, Eslava, Marcela, 2010. Electoral manipulation via voter-friendly spending: theory and evidence. J. Dev. Econ. 92 (1), 39–52.

Fearnside, Philip M., 2003. Conservation policy in Brazilian amazonia: understanding the dilemmas. World Dev. 31 (5), 757–779.

Fearnside, Philip M., 2005. Deforestation in Brazilian amazonia: history, rates, and consequences. Conserv. Biol. 19 (3), 680–688.

Ferraz, Claudio, 2007. Electoral Politics and Bureaucratic Discretion: Evidence from Environmental Licenses and Local Elections in Brazil Working Paper. http://www.cid.harvard.edu/neudc07/docs/neudc07_s1_p20_ferraz.pdf.

Ferraz, Claudio, Finan, Frederico, 2011. Electoral accountability and corruption: evidence from the audits of local governments. Am. Econ. Rev. 101 (4), 1274–1311.

Ferroukhi, Lyís, 2003. Municipal Forest Management in Latin America. vol. 236. Center for International Forestry Research, Bogor, Indonesia.

Foley, Jonathan A., Asner, Gregory P., Heil Costa, Marcos, Coe, Michael T., DeFries, Ruth, Gibbs, Holly K., Howard, Erica A., et al., 2007. Amazonia revealed: forest degradation and loss of ecosystem goods and services in the Amazon Basin. Front. Ecol. Environ. 5 (1), 25–32. Ecological Society of America.

Garcia-Navarro, Lourdes, 2015. Rich Nations Should Pay to Preserve Rain Forest Brazilian politician says National Public Radio. November 10, 2015. http://www.npr.org/2015/11/10/455432704/rich-nations-should-pay-to-preserve-amazon-rainforest-brazilian-politician-says.

Garcia-Navarro, Lourdes, 2016. Actions in Amazon Rain Forest Contradict Brazil's Promise National Public Radio February 24, 2016. http://www.npr.org/2016/02/24/467914398/actions-in-the-amazon-rain-forest-contradict-brazilian-governments-promise.

Garg, Teevrat, 2014. Public Health Effects of Ecosystem Degradation: Evidence from Deforestation in Indonesia Working Paper. https://www.sites.google.com/site/teevrat/research.

Gibson, Clark C., Lehoucq, Fabrice E., 2003. The local politics of decentralized environmental policy in Guatemala. J. Environ. Dev. 12 (1), 28–49.

Gingerich, Daniel W., 2014. Brokered politics in Brazil: an empirical analysis. Q. J. Polit. Sci. 9 (3), 269–300.
Goldemberg, Deborah, 2008. Brazil: do deforestation and elections mix? Global Voices. October 1, 2008 http://globalvoicesonline.org/2008/10/01/brazil-do-deforestation-and-elections-mix/.
Gonzalez, Maria de los Angeles, 2002. Do changes in democracy affect the political budget cycle? Evidence from Mexico. Rev. Dev. Econ. 6 (2), 204–224.
Grossman, Gene M., Helpman, Elhanan, 1994. Protection for sale. Am. Econ. Rev. 84 (4), 833–850.
Hargrave, Jorge, Kis-Katos, Krisztina, 2012. Economic causes of deforestation in the Brazilian Amazon: a panel data analysis for the 2000s. Environ. Resour. Econ. 54 (4), 471–494.
Instituto Pólis, 2008. The Challenges of Democratic Management in Brazil: the Right to the City. Instituto Pólis and Fundação Ford, São Paulo208.
INPE, 2014. PRODES: Sistema de monitoramento do desmatamento na Amazônia Legal. Instituto Nacional de Pesquisas Espacias (National Institue for Space Research), São Jose dos Campos, Brasil Dataset http://www.obt.inpe.br/prodes/index.php.
INPE, 2013. Metodologia para o cálculo da taxa anual de desmatamento na Amazônia Legal. Instituto Nacional de Pesquisas (National Institue for Space Research) Espaciais Coordenadoria Geral de Observação da Terra Programa Amazônia – Projeto PRODES, São Jose dos Campos, Brasil http://www.obt.inpe.br/prodes/index.php.
Jain, Arvind K., 2001. Corruption: a review. J. Econ. Surv. 15 (1), 71–121.
Khemani, Stuti, 2004. Political cycles in a developing economy: effect of elections in the Indian states. J. Dev. Econ. 73 (1), 125–154.
Kolstad, Ivar, Søreide, Tina, 2009. Corruption in natural resource management: implications for policy makers. Resour. Pol. 34 (4), 214–226.
Laurance, William F., Albernaz, Ana K.M., Schroth, Gotz, Fearnside, Philip M., Bergen, Scott, Venticinque, Eduardo M., Da Costa, Carlos, 2002. Predictors of deforestation in the Brazilian Amazon. J. Biogeogr. 29 (5–6), 737–748.
Lawson, Sam, Blundell, Art, Cabarle, Bruce, Basik, Naomi, Jenkins, Michael, Canby, Kerstin, 2014. Consumer Goods and Deforestation: an Analysis of the Extent and Nature of Illegality in Forest Conversion for Agriculture and Timber Plantations Washington, DC. Retrieved from http://www.forest-trends.org/documents/files/doc_4718.pdf.
Levitt, Steven D., 1997. Using electoral cycles in police hiring to estimate the effect of police on crime. Am. Econ. Rev. 87 (3), 270–290.
List, John A., Sturm, Daniel M., 2006. How elections matter: theory and evidence from environmental policy. Q. J. Econ. 121 (4), 1249–1281.
Nepstad, Daniel, Soares-Filho, Britaldo S., Merry, Frank, Lima, André, Moutinho, Paulo, Carter, John, Bowman, Maria, et al., 2009. Environment. The end of deforestation in the Brazilian Amazon. Science 326 (5958), 1350–1351.
Nolte, Christoph, Arun, Agrawal, Silvius, Kirsten M., Soares-Filho, Britaldo S., 2013. Governance regime and location influence avoided deforestation success of protected areas in the Brazilian Amazon. Proc. Natl. Acad. Sci. Unit. States Am. 110 (13), 4956–4961.
Nordhaus, William D., 1975. The political business cycle. Rev. Econ. Stud. 42 (2), 169–190.
Pattanayak, Subhrendu K., Pfaff, Alexander, 2009. Behavior, environment, and health in developing countries: evaluation and valuation. Annu. Rev. Resour. Econ. 1, 183–217.
Raile, Eric D., Pereira, Carlos, Power, Timothy J., 2011. The executive toolbox: building legislative support in a multiparty presidential regime. Polit. Res. Q. 64 (2), 323–334.
Ribot, Jesse C., Agrawal, Arun, Larson, Anne M., 2006. Recentralizing while decentralizing: how national governments reappropriate forest resources. World Dev. 34 (11), 1864–1886.
Ricketts, Taylor H., Soares-Filho, Britaldo, da Fonseca, Gustavo A.B., Nepstad, Daniel, Pfaff, Alexander, Petsonk, Annie, Anderson, Anthony, et al., 2010. Indigenous lands, protected areas, and slowing climate change. PLoS Biol. 8 (3).
Robinson, James A., Torvik, Ragnar, Verdier, Thierry, 2006. Political foundations of the resource curse. J. Dev. Econ. 79 (2), 447–468.
Rogoff, Kenneth, 1990. Equilibrium political budget cycles. Am. Econ. Rev. 80 (1), 21–36.
Sakurai, Sergio Naruhiko, Menezes-Filho, Naercio, 2011. Opportunistic and partisan election cycles in Brazil: new evidence at the municipal level. Publ. Choice 148 (1–2), 233–247.
Samuels, David J., 2001a. Money, elections, and democracy in Brazil. Lat. Am. Polit. Soc. 43 (2), 27–48.
Samuels, David J., 2001b. Does money matter? Credible commitments and campaign finance in new democracies: theory and evidence from Brazil. Comp. Polit. 34 (1), 23–42.
Samuels, David J., 2002. Pork barreling is not credit claiming or advertising: campaign finance and the sources of the personal vote in Brazil. J. Polit. 64 (3), 845–863.
Shi, Min, Svensson, Jakob, 2006. Political budget cycles: do they differ across countries and why? J. Publ. Econ. 90 (8–9), 1367–1389.
Shleifer, Andrei, Vishny, Robert W., 1993. Corruption. Q. J. Econ. 108 (3), 599–617.
Shukla, Jagadish, Nobre, Carlos, Sellers, Piers, 1990. Amazon deforestation and climate change. Science 247, 1322–1325.
Skole, David, Tucker, Compton J., 1993. Tropical deforestation and habitat fragmentation in the Amazon: satellite data from 1978 to 1988. Science 260 (5116), 1905–1910.
Smith, Joyotee, Obidzinski, Krystof, Subarudi, Subarudi, Suramenggala, Iman, 2003. Illegal logging, collusive corruption and fragmented governments in Kalimantan, Indonesia. Int. For. Rev. 5 (3), 293–302.
TI, 2013. Corruption Perceptions Index. Transparency International, Berlin, Germany Available from: https://www.transparency.org/cpi2013/results.
Wallace, Scott, 2007. Last of the Amazon. Natl. Geogr. Mag.. January, 2007 http://ngm.nationalgeographic.com/2007/01/amazon-rain-forest/wallace-text.
Watts, Jonathan, 2015. Amazon deforestation report is major setback for Brazil ahead of climate talks. The Guardian. November 27, 2015 http://www.theguardian.com/world/2015/nov/27/amazon-deforestation-report-brazil-paris-climate-talks.
WGI, 2013. Country Data Report for Brazil Worldwide Governance Indicators. World Bank, Washington, DC Available from: http://info.worldbank.org/governance/wgi/.