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Can the Political Left Save the Planet? Impact of Leftist Mayors on Deforestation in the Brazilian Amazon [1]

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Abstract: The paper argues that the political left in Brazil, who have often formed alliances with various workers' groups, are more likely to defend the environment and the indigenous people over-represented among the poor. This is because protecting the poor requires state intervention, which conflicts with the interests of businesses that seek to profit by using the rainforests for farming, cattle grazing, mining, and other activities. Using data from 760 municipalities in the Brazilian Amazon over 2000-2021, the paper examines the impact of left-wing Mayors on measures of environmental conflict and accord, including deforestation – levels and annual changes, area reforested, and local government expenses on environmental management. Using a fuzzy regression discontinuity framework, we identify the effects of left wing Mayors who won against right-wing Mayoral candidates in close elections on selected environmental outcomes. Results suggest that close elections of leftist mayors are associated with a significant drop in deforestation, increased reforestation, and higher environmental expenses, particularly when the leftist mayor is not in a coalition with other parties. The impact remains consistent irrespective of whether the mayors represent solely the left, a coalition of left and center-left parties, or workers' parties, though the influence is more pronounced for mayors solely from the left. These findings demonstrate that just as increased voter turnout that holds leftist Mayors accountable, leftist vote share is also greater in areas with more deforestation.

Keywords: Political representation of the left; Deforestation; Reforestation; Close elections; Regression discontinuity design; Local governments; Brazil.

JEL classifications: H77; Q56; R14;

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1. Introduction

The planet is currently engaged in an unspoken conflict with nature and those who defend it. The battle is taking place in the few remaining areas of the earth that are rich in biodiversity - such as forests, wetlands, and oceans - which are vital for maintaining the stability of the planet's climate and ecosystem. These areas are under threat from organized crime, corporations, and governments that seek to exploit their natural resources, such as timber, water, and minerals, for short-term gains, often through illegal means. Deforestation has reached unprecedented levels due to the timber, soy, cattle, and mining industries pushing the boundaries of the forest, which contributes to roughly 10% of global warming. The challenge now is to find the best way to prevent deforestation and ensure the sustainable management and preservation of tropical forests. This article explores how the local democratic processes may address deforestation.

This study focuses on Brazil. It contains 60% of the Amazon rainforest and has been in the spotlight for the burning and deforestation of the Amazon, which has particularly worsened during Bolsonaro's regime 2019-2023. This has caused global concern regarding the impact on the climate and greenhouse gas emissions. Dismantling of a number of earlier policies by President Bolsonaro has encouraged illegal extractive activities, exacerbating the issue. It is, therefore, essential to combat deforestation to address the imminent climate crisis. In 2006, the Law of Public Forest Management was introduced, which decentralized forest management by transferring jurisdiction from the central government to state environmental agencies. This law granted significant political, tax, and fiscal resources to municipalities, which are governed by Mayors elected every four years. The latter rationalizes our attempt to study the impact of political ideology of elected Mayors on selected environmental outcomes for combating deforestation.

Recent studies (e.g., Bratton and Ray 2002; Chattopadhyay and Duflo 2004; Franck and Rainer 2012; Pande 2003; Schwindt-Bayer 2006) on legislator identity have demonstrated that their personal characteristics can impact the policies they endorse. Various research works have shown that class plays a significant role in shaping people's attitudes and choices, both globally and in the US (Evans 2000; Hayes 1995; Korpi 1983; Manza, Hout, and Brooks 1995; Carnes 2012, 2013), although class consciousness is relatively weak in the US compared to other countries (Brooks 1994; Devine 1997). Using data from 18 Latin American countries, Carnes and Lupu (2015) have highlighted the unequal representation of social classes and also that lawmakers from different social classes possess different economic attitudes towards

legislative processes. Workers, for instance, prefer more statist policies, while businessmen and professionals tend to endorse market-oriented policies. This unequal representation of social classes has thus implications for the substantive representation of these classes too.

Building on these existing studies, we argue that the political left, as opposed to the political right that largely rests on various workers' alliances is more inclined to safeguard the environment and protect the welfare of the poor. Left-leaning politicians are more likely to support causes such as the environment and indigenous rights, as it usually entails greater government involvement to safeguard the poor who are disproportionately impacted by environmental disasters. This, in turn, creates additional costs for businesses. According to research conducted by Dunlap, Xiao, and McCright (2001) and Neumayer (2003), leftist Mayors in local government can play a crucial role in advocating for public policies that combat deforestation, preserve biodiversity, and maintain regional climate equilibrium. Furthermore, when the political left is not part of a coalition government, their impact is expected to be more pronounced since they do not have to compromise on their party's agenda.

We compile a unique municipality level data from 760 Legal Amazon municipalities over 2000-2021 from various official sources and examine the impact of left-leaning Mayors on various environmental conflict outcomes, including area deforested, changes in area deforested from last year, area reforested and annual environmental expenses. Deforestation data primarily comes from satellite monitoring from Prodes, a project in the National Institute for Space Research (INPE) with the goal of monitoring and controlling deforestation, among others. Prodes has better spatial resolution than other monitoring systems, e.g., Deter and can identify areas of size 6.25 ha or above annually. Since the mask is a blind spot for both PRODES and DETER, any changes to secondary vegetation in the Amazon remain invisible to both systems, and consequently, to Brazilian environmental authorities. The Terra Class project (Almeida et. al. 2016), a joint effort between INPE and EMBRAPA, partially addressed the problem of the invisibility of secondary vegetation in the Amazon by creating biennial maps of land use and cover within the PRODES deforestation mask, with secondary vegetation as one of the categories monitored. Accordingly, we have selected the following outcomes: (i) Prodes data on level and annual changes in deforestation; (ii) local government spending on environmental management (data from local government finance) and (iii) area reforested, data for which comes from Terra Class (available only until 2015). We have consulted several sources, including BBC Brasil, EU Manifesto project (limited coverage), Bolognesi, Ribeiro, Codato (2023) to convincingly identify party ideology, which is then used to classify leftwing (as against right wing) winner and runner up Mayoral candidates (see Appendix B).

The main challenge faced in studying the relationship between a left-leaning Mayor's election and the resulting environmental outcomes is the possibility of both being influenced by the same community characteristics, which can be observed or unobserved. To overcome this issue, we use close elections between left-wing and right-wing Mayoral candidates in a municipality within a fuzzy regression discontinuity (RD) framework. This allows us to randomise the election of a leftist as against a right-wing Mayoral candidate and vice versa, thus addressing the potential simultaneity between the election of a Mayor of given political ideology and the outcomes observed in the community. Accordingly, we use several proxies for a leftist Mayor: (i) Mayors for left only parties; (ii) Mayors from left and centre-left parties and (iii) Mayors from workers' parties (see Section 2.2 for further details).

Results show that close elections are more likely to result in the election of leftist mayors, and that these mayors tend to have a significant positive impact on selected environmental outcomes, including a reduction in annual deforested areas, an increase in area reforested and also an increase in expenses on environmental management– effects of a leftist Mayor is the largest for Mayors for leftist parties only. These results hold even when we consider the subsample of left wing Mayors winning/losing against the right-wing candidates. The study also finds that these effects are stronger in non-coalition local governments and in municipalities without budget deficit in a bid to identify the pure effect of leftist Mayors. We attribute these results to greater accountability of leftist mayors towards their clientele, including indigenous and poor people. Additionally, we document a significant positive association between deforestation, voter turnout, and leftist vote share, suggesting that voters too respond to deforestation by electing leftist mayors in a bid to save the environment.

We also note that the influence of leftist Mayors on environmental outcomes varies depending on some additional factors. Specifically, we noted that their impact is stronger in municipalities located farther from the Trans Amazon highway, when the mayor is not aligned with the President, and during non-election years. Despite the potentially positive impact of leftist mayors, these heterogenous findings highlight their limitations in protecting the Amazon, thus revealing areas that require more caution in addressing this environmental conflict.

We integrate various strands of the literature. The discussion of deforestation can be driven by the tragedy of the commons, a problem with the lack of social coordination as the core issue for renewable resources management (Stavins 2011). Deforestation occurs because it creates revenues from mining, logging, crops, cattle ranching, and land appreciation, thus ultimately, deforestation is necessary to prove or assure ownership. There is a sizeable literature

on the optimal management of forest resources (e.g., Dasgupta and Heal 1974, Samuelson 1976, Dasgupta 1982, Brown 2000). Accordingly, we focus on the importance of local governance for the local environmental management and protection.

Existing literature highlights that legislator characteristics, such as gender and ethnicity, have important consequences on their policy choices. In India, policy outcomes differ depending on the proportion of lawmakers who are women (Pande 2003) or from lower castes (Chattopadhyay and Duflo 2004). In the United States and Western Europe, female legislators behave differently from male legislators (Bratton and Ray 2002; Mansbridge 1999). In Latin America too, female legislators consistently hold different political attitudes and initiate different legislation than their male counterparts (e.g., Jones1997; Schwindt-Bayer 2006). In Africa, lawmakers from certain ethnic backgrounds improve their ethnic group's well-being (Franck and Rainer 2012). Most common measure of social class of legislators appears to be linked to their prior occupations; occupational backgrounds tend to be strong predictors of income, social status, and the class labels people assign to themselves (Hout 2008; Katz1972, 63). Further, occupations are plausible drivers of what people think about public policy than many other measures. We contribute to this strand of the literature by focusing on the political ideology of elected Mayors.

Recent political economy literature, however, emphasises that the local politicians and bureaucrats gain significantly through logging. Burgess et al. (2012) had particularly argued that the higher the number of political jurisdictions, the greater the extent of deforestation in Indonesia. They also found a political logging cycle where illegal logging increases dramatically in the years leading up to local elections. Brollo et al. (2013), showed that larger central transfers increase the observed corruption and reduce the average education of Mayoral candidates in Brazil. Concerning deforestation in the Peruvian Amazon, Medina et al. (2020) reported that the re-election of subnational authorities (mayors) reduces deforestation in zones where the central government presence is limited. Along these lines, we also consider the effectiveness of leftist mayors in election years, in coalition governments and also when the mayor is aligned with the President.

Finally, we consider the literature on the trade-off between descriptive and substantive representation. While *descriptive* representation means having a diverse group of representatives, *substantive* representation requires representatives having control over policy outcomes affecting their voters. The literature suggests that descriptive representation may (Preuhs (2007)) or may not (Lublin, 1997) necessarily lead to substantive policy changes, especially if the size of descriptive representation is small. Research on mass political

behaviour have established that the attitudes and choices of people all over the world are divided by class (e.g., Evans 2000; Hayes 1995; Korpi 1983; Manza, Hout, & Brooks 1995). Carnes & Lupu (2015) have further highlighted the unequal descriptive representation of social classes, especially workers. Workers, for instance, prefer more statist policies, while businessmen and professionals tend to endorse market-oriented policies. Arguing that an unequal representation of social classes has implications for their substantive representation in a democracy, we explore whether the class-based political ideology of elected Mayors may generate substantive changes in environmental outcomes. As far as we are aware, this is the first paper to examine the role of the political left based on various workers' alliances on various environmental outcomes in the Brazilian Amazon and we hope that these results will have relevance beyond the Brazilian borders.

The paper is developed as follows. Section 2 discusses a history of public policy development in Brazil for the protection of the Amazon and then develops the hypotheses of interest. Section 3 explains the process of data collection and also its description. Section 4 describes the empirical strategy and analyses the findings. The final section concludes.

2. Background

Brazil's federal structure comprises of 26 states, a federal district, and more than 5,590 third-tier governments, the municipalities. Sixty per cent of the Amazon rainforest is located in Brazil's Legal Amazon containing 9 states in the Amazon basin. Our study focuses on the 760 municipalities located in the 9 states in this Legal Amazon area.

Since the Brazilian Constitution of 1934, legislating about indigenous issues is a federal competency. However, the history of Brazilian indigenous protection rights started only with the 1988 Constitution. All previous Brazilian Constitutions (1937, 1946, 1967, and 1988) recognized the right of indigenous to have their land protected. However, only the 1988 Constitution defined what is protected and indigenous land, which fosters land demarcations as of 1990. Having a clear definition of the indigenous land was fundamental to enforce rights since it became possible to demarcate the lands to be protected (Cunha 2018).

The 1988 Constitution also brought legal representation for indigenous people, affirming the legal capacity of the Indians and their forms of organization, entrusting their defence to the Public Ministry. Before the Constitution, the indigenous people were considered relatively incapable people, thus they could not take legal actions to represent themselves. This

previous design aimed to protect the indigenous people but resulted in legal incapacity in practical terms (Cunha 2018).

The 1988 Constitution proposed decentralization of governance from the federal government – keeping, however, the planning of public policies, the leading role of the sub-national spheres, which should implement the national policies, and responsibility for funds to finance the localities, to states and municipalities. As the fiscal autonomy of localities was designed to be staggered throughout the years, the Constitution granted considerable political, tax power, and large resource transfers from the central government to states and municipalities. The new Constitution specified that the municipalities should execute the policies planned by the central government, while states should collaborate on financing and executing policies more complex and involving increasing returns of scale.

The Amazon has a peculiar case of property rights. The impression that Brazilians have is that it is "a no man's land" and this is the biggest part of the problem involving deforestation and land grabbing in the area (https://www.bbc.com/portuguese/brasil-56148670). There were land reform efforts to migrate part of the Brazilian population there in an attempt to "give land" to anyone who wanted to be a rural producer.

2.1. Recent interventions for the protection of the Amazon

The year 2006 witnessed the introduction of a law for the legal registration of forest areas. Several real estate registration agencies started to register rural properties (all over the country, including areas in the Legal Amazon).[2] The demarcations opened up the possibility of making numerous Indigenous Lands, that have not yet completed their formal procedures. Thus, there is still a great need for land demarcation. According to data from the *Conselho Indigenista Missionário* (CIMI), 63% of Indigenous Lands are not legalised. In other words, of the 1,290 Indigenous lands, 821 are in a precarious situation because they have not homologated the demarcated boundaries. Most of these have not even commenced their legalisation procedures. The following are the numbers of Indigenous Lands approved during the different presidential terms:

- Fernando Henrique Cardoso (1995 - 2002): 145 approvals.
- Luiz Inácio Lula da Silva (2003 - 2010): 79 approvals.
- Dilma Rousseff (January 2011 - August 2016): 21 approvals.

[2] See an excellent historical overview - https://imazon.org.br/quem-e-dono-da-amazonia-uma-analise-do-recadastramento-de-imoveis-rural/

- Michel Temer (August 2016 - December 2016): 1 approval.
- Jair Bolsonaro (January 2019 - to date): 0 approvals.

This constant decline in approvals of Indigenous Lands during each presidential term reveals the increasing lack of relevance of these peoples, now considered the major obstacle to Brazil's neoliberal development project (Ref: https://www.iwgia.org/en/brazil/4204-iw-2021-brazil.html). In short, the federal government still does not know who owns a large part of the Legal Amazon. What is known is that areas demarcated as Conservation Units and Indigenous Lands are managed by the public sphere, whether state or federal. While many other areas of forest are still undesignated, leaving room for illegal tenure.[3]

Recent research (Baragwanatha and Bayi, 2020) suggests that indigenous people in the Brazilian Amazon with full ownership rights over their land saw a two-thirds decrease in the rate of deforestation on their land in the world's most important rainforest.[4]

To govern indigenous lands, additional laws have been implemented since 1988. With the New Forest Code of 2012 (Law No. 12.651/2012) the federal government implemented the online platform CAR (Cadastro Ambiental Rural, or rural environmental register), whose function is to receive the land's self-declaration.[5] The individual enters there, georeferences his rural property, claims to be the owner and then his request is analysed. The CAR is within the scope of the National Information System on the Environment, SINIMA, regulated by Normative Instruction MMA No. 2, of May 5, 2014, the Rural Environmental Registry, an arm of the Brazilian Forest Service. Thus, the CAR is an electronic public record of scope national, mandatory for all rural properties, in order to integrate the environmental information of rural properties and possessions related to Permanent Preservation Areas PPA, of restricted use, Legal Reserve, forest remnants and other forms of native vegetation, and of the consolidated areas, composing a database for control, monitoring, environmental and economic planning and combating deforestation.

Another innovation of the Forest Code was a plan to implement the Environmental Regularization Program (Programa de Regularização Ambiental - PRA) at state and federal district levels in the whole country. General rules of the PRA are set out in Decree 7,830/2012. The PRA includes a set of actions to be developed by rural landowners and squatters with the objective of promoting the environmental regularization of their properties or possessions. To

[3] For further information see: https://www.sciencedirect.com/science/article/pii/S0264837720302180.

[4] https://www.scientificamerican.com/article/amazon-deforestation-falls-where-land-is-under-indigenous-control/

[5] https://www.embrapa.br/codigo-florestal/entenda-o-codigo-florestal

adhere to the PRA, states and the federal district must register rural properties in the CAR. Formal adhesion to the PRA includes the signing of a Term of Commitment that contains, at least, the commitments to maintain, recover or restore degraded areas or altered areas in PPA, Legal Reserves and Restricted Use of the rural property, or to compensate Legal Reserve Areas. The restoration project for degraded and altered areas is one of the instruments of the PRA and the activities established therein must be completed in accordance with the schedule provided for in the Term of Commitment. As of the signing of the Term of Commitment, sanctions resulting from infractions related to irregular suppression of vegetation in PPAs, Legal Reserves and Restricted Use Areas committed before 07/22/2008 will be suspended.

Chapter X of the Forest Code includes the provision for the institution of the "Program to support and encourage the preservation and recovery of the environment", including the incentive for the adoption of technologies and good practices that reconcile agricultural and forestry productivity, with the reduction of environmental impacts, as a way of promoting ecologically sustainable development. Among the incentives, there is the payment or incentive for environmental services as retribution, monetary or not, for the activities of conservation and improvement of ecosystems that generate environmental services, and compensation for necessary environmental conservation measures, including credit, tax and commercial benefits.

From the point of view of agricultural production, the implementation of Law 12,651/2012 is of special importance, given the recognition of the positive impacts on the countryside in the search for sustainable production. Such benefits, also appropriated by urban society, directly or indirectly, are related, among others, to the provision of environmental services guaranteed by the maintenance of native vegetation in part of the rural property, as in the maintenance of populations of beneficial organisms, such as pollinators of crops and natural enemies of pests; in soil protection and control of erosion processes, in geological stability, in the production and supply of water for various purposes, among others. Data, however, shows that the progress of this Law has been rather limited in this respect – apart from a tiny minority, most requests are "under analysis", "awaiting analysis" or "reviewed with pending issues, awaiting resolution".

2.2. Political representation of the left in Brazil

In Brazil, mayoral elections take place every four years, alternating with state and presidential elections that happen in between. Voting is mandatory for individuals aged 18 to 70, while illiterate, incapable persons, 16 and 17 year olds, and those over 70 can choose whether or not to vote. In the majority of municipalities, mayors are elected through a first past the post

system. However, if a municipality's population exceeds 200,000, an outright majority is necessary to win, or else, a second round runoff election will be held. We consider the final round of the election that resulted in a leftist candidate competing against a rightist candidate for the mayoral position and vice versa.

There are various methods for measuring the ideology of political parties, such as analyzing their party programs, observing the behavior of party representatives, examining their electoral behavior, considering public perception of party representatives, and consulting experts in the field. To classify party ideology, we have consulted several sources, including BBC Brasil, EU Manifesto project, Bolognesi, Ribeiro, Codato (2023). However, we were unable to use the Manifesto project extensively due to its limited coverage of parties. Bolognesi, Ribeiro, Codato (2023) relied on expert opinions to classify party ideology, while BBC Brasil analyzed the results of ten recent and relevant votes in the Chamber of Deputies. In Appendix B, we have summarized the classification of party ideologies using BBC Brasil and Bolognesi, Ribeiro, Codato (2023), which are generally consistent when classification exists for both sources. This has allowed us to classify the parties of elected municipal Mayors and runner-up candidates into categories of center, center-left, left, center-right, and right as follows:

Left: "PCB", "PC_B", "PCO", "PDT", "PMN", PSB, PSOL, PSTU, PT & PV
Centre-left: "AVANTE" "CIDADANIA", "PROS" "SOLIDARIEDADE" "PPS", "REDE"
Centre: "PMDB".
Centre right: PSDB, PMB, MDB, PSD, DC PRP
Right: PL, PTB PATRIOTA, PODE, PP, PRTB, PSC, PTC, DEM, Republicanos, PPB, PR, PRB and PSC, PSL.

Without much loss of generality, we find that left parties in Brazil had close association with the workers' unions and they often promoted socialism, anti-capitalism in a bid to fight poverty. For example, PT is the workers' party launched by the Brazil's main federation of labour unions after the military cue and ruled the country between 2002-2016. PT and PSDB (Brazilian Social Democracy Party) were the biggest adversaries in contemporary Brazilian politics from 1994 to 2014, with their candidates finishing either first or second on the ballot on the last six presidential elections. PSTU, the United Workers Socialist Party, too has its origin in Workers' League. While PSB is the Brazilian Communist Party, PCO is the workers' cause party that united with the PT in 1980. PMN is the National Mobilisation Party that advocated for agrarian reform, termination of debt payments, ending of relations with the International Monetary Fund and formation of a trade bloc with other South American

nations. PSOL is the Socialism and Liberty Party related to socialism, anti-capitalism, and anti-imperialism; there are eco-socialists too. The party program focuses on the reduction of working hours, agrarian and urban reform, increased spending on health, education and infrastructure, and a break with the International Monetary Fund. PV is the green party directly committed to social equity and sustainable development. Similarly, many of the centre-left parties including CIDADANIA, PROS, SOLIDARIEDADE, PPS generally adhered to the principles of socialism and anti-capitalism and often formed coalition with PT. Rede is an environmentalist political party while AVANTE is centrist party formed by the dissidents of the Brazilian Labour Party.

In contrast, centre and centre-right Brazilian parties are more allied with the businesses. Among them PMDB, MDB are parties without a clear ideological program and has often allied itself with the executive to extract advantages through clientelistic networks. PSB too has aligned with both the left and the right in recent years. PMB is the Brazilian Women's Party Known for its non-feminist and anti-abortion stance while DC (Christian Democracy) is a small party supporting traditional Christian values. Jair Bolsonaro was a member of DC from 1988 to the merging with Democratic Social Party lately. DC under Bolsonaro had the flagrant disdain for minority rights, which struck a chord with a population increasingly disillusioned with PT's redistributive politics and economic corruption. In the process, Bolsonaro had won the backing of Brazil's business elite by promoting pro-market views.

Using the above party ideology classification, we create a number of proxies for left-wing Mayors: (a) Mayors from the Left and Centre-Left parties taken together. (b) Mayors from the left parties only. (c) Further, we construct an index to identify the parties that best represent the workers' (as against business) interests. Most parties cite the workers' rights as one of the key objectives. Thus, to disentangle the most prominent parties that defend workers' interests, we consider the ones that has "workers" (trabalhadores or operários in Portuguese) as one of the words in the party's acronym. (a)-(c) are the parties, who are generally pro-workers, pro-poor and often pro-environment too. (d) Since 2016 municipal elections, we are also able to identify if the local government has any elected indigenous members. The latter provides an alternative way to assess the role of leftist Mayors (a)-(c) on these municipalities with elected indigenous members. We find a high degree of correlation between election of an indigenous member and that of the leftist Mayors.

Figure 1 shows the trend in average leftist mayor shares in the sample municipalities over the years 2000-2018. Panel a illustrates the trend of left and centre-left Mayors while panel b

shows the corresponding trend for left only Mayor shares over 2000-18. Evidently, there has been an increasing share of leftist mayors in the Amazonian municipalities between 2000-12. The share, however, had dropped subsequently until 2015 and stabilised thereafter though still lower than the peak of 2010. The latter coincides with the gradual collapse of the PT government led by President Lula at the federal level as it was increasingly plagued by various corruption scandals and economic crises. Similar declining trend is observed for the Mayors from workers' parties after 2010.

*** Insert Table 1 here ****

Table 1 reports the likelihood of having a leftist mayor- columns (1)-(2) show the estimates of left party (left plus centre-left), columns (3)-(4) those of left only party Mayors and columns (5)-(6) those of Mayors from workers' parties. Row (1) shows the estimate of indigenous population (as a share of 10000) while row (2) shows that of indigenous population as share of the municipality population. Evidently, there is a positive and significant association between the indigenous population (level or share) in a municipality and the likelihood of having a leftist Mayor. We therefore take the election of a leftist Mayor as representing the indigenous population of the municipality.

In view of the local election data from 2016 onwards, we also consider the likelihood of a municipality with elected indigenous members. Note that this information is not available for prior elections. Our analysis shows that the likelihood of having an indigenous elected member is significantly higher (0.12 as against 0.066 with a t-statistic of 6.3830) when the mayor is from a left-leaning party (left or centre-left in our classification). This information provides an additional tool to further test the role of political representation of the indigenous people on deforestation in the Brazilian Amazon in our analysis. This positive association is also confirmed in Table 1.1 where we regress the number of elected indigenous members on the likelihood of having a Mayor from left only, left and centre-left or workers' parties.

Coalition governments are very common in Brazilian municipalities. The likelihood of having a coalition government is about 0.36 when the mayor represents the left or a centre-left party. We also note that many mayors are aligned with the President in terms of their party affiliation and this likelihood (0.26 as against 0.06 for others with a t-stat of 35.5624) is significantly higher among left-led municipalities in Brazil. The latter can probably be attributed to the fact that the centre-left Partido dos Trabalhadores under President Lula ruled for much of the sample period (2003-16).

2.3. Central hypothesis: Why leftist Mayors can better tackle deforestation?

In this context, we develop our central hypothesis and suggest that local conservation efforts in the Amazon hinge on effective political representation from left-leaning and indigenous groups.

The ancestors of the Amazon's indigenous people had spent thousands of years learning how to regenerate their native ecosystem and improve its characteristics for the betterment of their own community. Recent studies conducted in the Western Amazon show that these native communities are trustworthy caretakers of their ancestral lands. In the Bolivian Amazon, indigenous land ownership was found to be strongly correlated with the fate of the forest, as private settler and bushman holdings were responsible for the majority of old-growth forest loss.

From 1995 to 2002, Brazil was governed by the Brazilian Social Democracy Party, a center-right political party, and from 2003 to 2016, it was governed by the Workers' Party, a center-left party. During this time, the Federal government implemented several regulations, including the 2006 land registration law and the 2012 New Forest Code (see Section 2.1). However, since the election of Jair Bolsonaro, a far-right president from the Social Liberal Party in 2018, many policies protecting the Amazon's indigenous groups have been rolled back. Bolsonaro has facilitated the destruction of the Amazon through deforestation and has been accused of promoting illegal mining and logging in the region. Additionally, he has weakened environmental agencies and ignored concerns from Brazil's indigenous communities regarding the growing invasion of their lands.

The rapid deforestation in the Amazon from the 1960s to the early 2000s was caused by various factors, such as public investments in roads, the promise of land titles and subsidized credit for cleared land, and the allocation of land to farm families from other regions in "agricultural reform" settlements. This was a government policy aimed at developing the North region of the country. However, in the mid-2000s, the federal government, led by the Workers' Party PT, changed its approach and implemented policies to reduce deforestation. These policies included establishing protected areas, increasing monitoring and enforcing federal laws that limit the conversion of forested land, and obligating private landowners to conserve the forest (West and Fearnside 2000). The New Forest Code of 2012 introduced several measures, such as an online platform (CAR), the Environmental Regularization Program, and a Program to support and encourage the preservation and recovery of the environment. Incentives were also provided to municipalities to reduce deforestation, and a "black list" was

created to identify the municipalities with the highest rates of deforestation, subjecting them to stricter enforcement and limited access to credit and agricultural markets (Cisneros et al. 2015). As a result of these measures, significant progress has been made in reducing deforestation.

Accordingly, we contend that having left-leaning mayors in power may result in more environmentally friendly policies compared to their right-wing counterparts. This is likely due to several reasons: firstly, protecting the environment often requires government intervention; secondly, it can impose costs on businesses; thirdly, it tends to benefit the poorer sections of society, who are more likely to suffer from environmental conflicts than the wealthy (as highlighted by Dunlap, Xiao and McCright in 2001 and Neumayer in 2003); and finally, left-wing parties, which are often driven by workers in Brazil, tend to favour state intervention over market mechanisms (as pointed out by Carnes and Lupo (2015)). Therefore, we predict that mayors from left-wing parties are more likely to introduce government policies to address deforestation and protect the environment, even if it comes at the cost of local businesses, as they want to support their traditional voters who are often from the working class and are relatively poor.

However, the effectiveness of left-leaning mayors in promoting environmentally friendly policies may be limited if they are part of a coalition government with other parties that have conflicting interests. This means that a left-leaning mayor's ability to protect the environment may be hindered if there are disagreements between their coalition partners in the local government. Second, some argue that promotion of business interests in the rainforest area is primarily aimed at generating additional funds, particularly when the local government faces budget deficits. The latter induces us to test the validity of this argument.

Finally, we expect some heterogeneous impact of leftist Mayors in the following cases: (a) if the municipality is accessible to the TransAmazon highway with easy access to outsiders; (b) if it is an election year; (c) if the mayor is aligned with the President.

First, easy access to the trans-Amazon highway may make a municipality more amenable to poachers and illegal loggers doing damage to the Amazon. As such, the efficacy of the left-led municipalities to tackle deforestation and other environmental issues is likely to be higher when the municipality is not easily accessible. Second, we expect that the effectiveness of a leftist Mayor is likely to be less in election years since the environment and the indigenous causes are hardly vote winners in Brazil. There is likely to be more emphasis on jobs, inequality and poverty during the election years. Finally, the effectiveness of leftist Mayors may also vary depending on whether the mayor is aligned with the President. We contend that a leftist mayor is likely to be more effective when non-aligned with the President,

especially if the President is from a different party. Alignment with the President or any other party may give rise to conflict of interests, which may lower their efficacy for tackling environmental conflict. We use the available data to test these hypotheses.

3. Data Description

Nine of Brazil's 26 states contain some 60% of the Amazon, a habitat that constitutes half of all remaining tropical rainforests and that spans nine countries. These 9 states have 760 municipalities, which are the focus of our analysis.

We collect data on Legal Amazon over 2000-2021 from a variety of official sources: IBGE- Brazillian Institute of Geography and Statistics, Water Agency, DNIT - Infrastructure, MMA – Ministry of Environment, TSE – Superior Electoral Court, IPEA- Institute of Applied Economic Research, SUS- National Health Service, CPT- Pastoral Land Commission, Tesouro Transparente - Transparency National Treasure. This is summarised in Appendix Table A1.

The key outcome variables of our interest are: (i) area deforested in square km (PRODES); (ii) change in area deforested in square km (PRODES); (iii) area reforested (TC); (iv) expenditure on environment management. In general, mechanical clearance using bulldozers and other heavy equipment is estimated to cost 44-70% more than using fire (Simorangkir 2007). MODIS satellite data for detecting all fires across the world for the period 2003-2018 suggests that the incidence of fires is concentrated heavily in forested low-income countries and is about four times higher than that in forested high-income countries.

Panels a-b of Figure 2 show the trends in deforested areas, levels as well as annual changes, in our sample. Between 2000-2004, there is high degree of deforestation in Brazil (see panel a); however, deforestation started falling sharply (see panel b) from 2005 onwards as the Lula government initiated a number of policies to conserve the Amazon. However, there was reversal of the policies to tackle deforestation as the country entered a period of economic crisis after 2014, which was further bolstered by the election of Bolsonaro since 2019. This is further corroborated in the panel c figure that shows the trend in local government expenses on environmental management: it grew steadily until about 2014 and then started falling.

3.1. Comparison of municipalities ruled by leftist and non-leftist Mayors

Table 2 summarises the selected characteristics of municipalities ruled by leftist and non-leftist Mayors. In this case, we consider the broader definition of leftist Mayors where we add Mayors

from the left and centre-left parties together in our sample. Column (1) shows the means for municipalities ruled by leftist Mayors, column (2) shows those for municipalities ruled by non-leftist Mayors while column 3 shows the corresponding t-statistics for comparisons of means between these two groups of municipalities.

*** Insert Table 2 here ****

We summarise the key differences between municipalities ruled by leftist Mayors and others.

(i) Left-ruled municipalities are significantly bigger both in geographic size and population.

(ii) Left-ruled municipalities tend to have significantly higher indigenous populations – both total and share of the total population.

(iii) Voter turnout is significantly higher in the left-ruled municipalities.

(iv) Left-ruled municipalities taxes businesses more (higher ISS tax revenues) that help them spend significantly more on indigenous assistance and also on environmental management including environmental control, mining, land use, agricultural organisation, water management, recovery of soil degradation.

(v) Share of poor population is significantly lower in left-ruled municipalities.

4. Empirical Strategy and findings

Having described the data in the previous section, we shall, in this section, examine whether/how the election of the leftist Mayors can lower deforestation and boost reforestation in the Amazon municipalities, especially when not in coalition with other parties.

The main empirical challenge has been that the election of a leftist Mayor in a municipality is unlikely to be random. It is likely to depend on the same municipality characteristics that also determine the deforestation outcomes of our interest. We use a regression discontinuity (RD) framework to use close elections between left-wing and right-wing Mayoral candidates in our sample. The underlying idea is that close elections would randomise the elections of a leftist Mayor against a right-wing candidate and vice versa, thus enabling us to obtain the causal effects of the election of left-wing mayors in the local municipal elections on various outcomes pertaining to conflict and deforestation.

The RD design is one of the most credible non-experimental strategies used in the literature. It relies on weak and easy-to-interpret nonparametric identifying assumptions, which

permit flexible and robust estimation and inference for local treatment effects. The key feature of the design relies on the winning margin of a left-wing candidate against a right-wing one, which is used as the key running variable for each Amazon municipality in the sample. This determines the treatment assignment via hard-thresholding around the cut-off winning margin of 0 (to characterise a close election). In particular, all municipalities that elect a left-wing candidate against a right-wing one with a winning margin above the cut-off 0 are offered the treatment, while all units whose score is below this cut-off 0 (i.e., where a left-wing candidate loses against a right-wing one) are not. Identification is then done by comparing the responses of units near the cut-off of 0 winning margins, taking those below (comparison group) as counterfactuals to those above (treatment group).

Close elections are defined as those in which the winner and the runner-up are of opposite ideologies and the margin of victory is so small (very close to the cut-off threshold of 0) that the ideological identity of the winner of a close election turns out to be quasi-random. To see this, the probability of being elected is a function of the vote difference between the winner and the runner-up and this function has a discontinuity at zero. As the vote difference approaches discontinuity, constituencies in which a left candidate wins by a small vote margin are increasingly similar to constituencies in which a right-wing individual win by a small margin (Lee 2001; Pettersson-Lidbom 2001), making the experimental framework quasi-random.

Figures 3a and 3b show the RD plots of the selected deforestation and reforestation outcomes, namely, area deforested, annual change in area deforested and area reforested (all measured in square km), using linear (panels A-C), quadratic (panels D-F) and cubic (panels G-I) polynomials using 3% bandwidth. We plot left-wing win margin on the horizontal axis. Positive win margin indicates that a left-wing Mayoral candidate wins against a right-wing one and vice versa when the left-wing win margin is negative. We plot a lowess smoothing line for each of the selected outcomes on each side of the cut off win margin c=0 in each panel respectively using linear, quadratic and cubic polynomials. In general, we observe an increase in area deforested at c=0 when a left-wing Mayoral candidate wins against a right-wing one (see panels A, D and G) in close elections. In contrast, there is a reduction in area deforested from last year when a left-wing Mayoral candidate wins against a right-wing one (see panels B, E and H) in close elections, respectively using linear, quadratic and cubic polynomials. Finally, panels C, F and I show a small positive effect on area reforested when a left-wing Mayoral candidate wins against a right-wing one in close elections respectively for linear, quadratic and cubic polynomials. We get to similar conclusion if we consider Figure 3b for the

RD plot of outcomes among left only Mayors. The corresponding figure for workers' party Mayors is shown in Appendix Figure A2, which too confirms similar patterns in outcomes around the winning margin cut-off of 0. Finally, Figure 3c shows the RD plots of natural logarithm of environmental expenses for all three proxies of the leftist Mayors – left plus centre-left, left only and workers' party. In general, these plots indicate an increase in environmental expenses under all proxies for leftist Mayors at the winning margin 0. Since the jump in these selected outcomes at the threshold level of winning margin equal to zero is small, we use a fuzzy regression discontinuity (RD) design.

4.1.Identification

Before proceeding with the RD robust estimates of the outcomes, we need to establish that the identifying assumptions hold in our sample. First, we check whether the running variable, i.e., the winning margin, is continuous at the cut-off point 0. Figure 4a shows a histogram of the running variable for the entire range of winning margin (positive when a left party (left and centre-left) Mayoral candidate winning against a non-left party candidate and negative otherwise) in bins of 2 percent. This evidently supports the continuity of the left party candidate's winning margin at the cut-off 0. Figure 4b shows the corresponding histogram when a Mayoral candidate from left only party wins, which too confirms the continuity of the running variable, i.e., winning margin.

A useful attribute of the RD design applied to Amazonian municipalities is that voter fragmentation across different candidates up for election leads to close elections over a wide range of underlying left party vote shares. Note that we only consider the final round of the vote for the Mayoral election. This is illustrated in Figure 5a, which shows the left party winning margin (the difference between the vote share for a left-wing councillor winning against a non-left runner-up, a non-left candidate) against left party vote share on the horizontal axis. Observations within 2 percentage points of the winning margin threshold at zero are shown in red. The diagonal line is the hypothetical one-to-one relationship between the two variables. Observations close to the horizontal line marking the winning margin cut-off around 0 vary from just under 2 percent (with votes split across many candidates up for election) up to 50% (with votes more concentrated across fewer candidates up for election) of the total votes cast for a left party candidate. We get very similar picture even when we consider candidates from left only parties winning against right-wing ones. The RD treatment effect is thus not singular to a specific preference point, but representative of a more heterogeneous constellation

of political circumstances. This has the additional benefits that a core assumption of the design – that left party preferences are continuous over the threshold – can be explicitly demonstrated.

Balancing of the covariates

For the RD robust model with covariates, we also need to ensure that the treatment have no effect on the covariates at the cut-off, and that the conditional expectations of potential outcomes and covariates given the score be continuous at the cut-off.

Accordingly, we test the balancing of the covariates around c=0. This is shown in Figure 6 using polynomial of order 1 (panel A-G) and order 2 (panel H-N). We plot a lowess smoothing line for each of the possible covariates on each side of c=0 in each panel.

Chosen covariates are municipality's log(population), log(area in km), 15+ illiteracy rate, indigenous population share, male population share, distance from the nearest highway and also if receives any oil royalty. These figures confirm that our chosen covariates are balanced around c=0 irrespective of the choice of the polynomial.

4.2. RD Robust estimates

Having established that the identification conditions hold in our sample, we argue that the election of a leftist (against a rightist) Mayor in a close election is likely to be random around the cut-off of 0 winning margin. In particular, we assume that the treatment assignment, m_{it}, for the i-th municipality in t-th election is determined solely based on a cut-off score, c, on an observed forcing variable, xi. We take the forcing variable x to be the winning margin for a leftist Mayor relative to a non-leftist one; the cut-off is c = 0 as we consider close elections. The municipalities that fall below the cut-off (c = 0), constitute the control group (mi =0) that elects a non-leftist Mayor who ran against a leftist Mayoral candidate. Those above the cut-off, the treatment group (mi = 1), elect a leftist Mayor who ran against a non-leftist candidate. The assignment follows a known deterministic rule, mi = 1 {xi ≥ c}, where 1{•} is the indicator function.

Accordingly, we consider the following specification for estimating the fuzzy RD estimates of the selected deforestation outcomes Y_{it} of the i-th municipality in t-th election cycle in response to the treatment m:

(Equation 1) $Yi = \alpha\, \beta m_i + f(xi) + \varepsilon i \; \forall\, xi \; \varepsilon\, (c - h,\, c + h)$

where Y_i is the selected deforestation outcomes in question, m_i is the treatment (when a leftist Mayoral candidate wins against a right-wing candidate), x_i is the forcing variable (i.e., winning margin), and h is the neighbourhood around the cut-off c of the forcing variable x, referred to as the bandwidth. We experiment with bandwidth h=0.03 and also optimal bandwidth to indicate close elections, as commonly used in existing studies. The control function f(xi) is some continuous function, usually, a n-th degree polynomial in the forcing variable on each side and we experiment with linear, quadratic and cubic polynomials.

We attach higher weights to observations closer to the cut-off, which is standard in the regression discontinuity literature. We obtain the robust RD estimates proposed by Calonico, Cattaneo and Titunik (2014a; 2014b) that implements local polynomial Regression Discontinuity (RD) point estimators with robust bias-corrected confidence intervals and inference procedures. The advantage here is that these estimates are robust to "large" bandwidth choices. The programme reports three different procedures: i) conventional RD estimates with a conventional variance estimator; ii) bias-corrected RD estimates with a conventional variance estimator; and iii) bias-corrected RD estimates with a robust variance estimator. Option (iii) remains our preferred estimates. Following Gelman and Imbens (2014), we focus on linear and quadratic polynomials because higher order polynomials increase the volatility of the estimates.

4.2.1. First stage estimates of the likelihood of having a leftist Mayor

We start by considering the first stage estimates to explore the effect of winning margin on the likelihood of having a leftist Mayor. This is summarised in Table 3 that shows conventional, bias-corrected and the robust estimates with covariates. Our preferred estimates are the robust ones, which are robust to large bandwidth choices.[6]

*** Insert Table 3 here ****

All estimates are positive and statistically significant, irrespective of the choice of the polynomials, indicating that the likelihood of having a leftist Mayor is significantly higher for a close election with a margin of 3% and this likelihood goes down somewhat as the degree of the polynomial goes up from 1 to 3. The mean value of the likelihood of having a leftist Mayor is 0.24 (standard deviation of 0.4275). All the robust coefficients are again positive and

[6] RD robust estimates without covariates are summarised in Appendix Table A3.

statistically significant when we consider the close election margin 5%. We get similar results even when we use the optimal bandwidth option (see Appendix Table A4).

The rest of the paper makes use of the conventional 3% bandwidth widely used in the literature. Given that we are using the robust RD estimates, these estimates with 3% bandwidth are also robust to "large" bandwidth choices.

4.2.2. Effects of leftist Mayors on deforestation outcomes: Full sample results

Tables 4-5 show the treatment effects of leftist Mayors on area deforested, annual change in area deforested, area deforested and environmental expenses in close elections of left only, left and centre left as well as workers' party Mayors.

*** Insert Table 4 here ****

Table 4 shows the estimates of area deforested and annual change in area deforested with a bandwidth of 3% for the full sample with covariates. All observations are weighted in such a way that the observations close to the cut-off point of winning margin 0 get higher weights. All standard errors are clustered at the municipality level.

We focus on the estimates with covariates because covariates can reduce sampling variability without increasing bias in the best scenario. Included covariates are: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share, if the municipality is protected indigenous land, distance from the TransAmazon highway, if the municipality receives oil royalty share and if it is an election year.

Columns 1-3 show estimates for left and centre-left Mayors, columns 4-6 those for left only Mayors while columns 7-9 those for workers' party Mayors. Evidently, all treatment effects are negative in Table 4, but the robust treatment effects are statistically significant only for annual change in deforestation area since last year (see columns 4-6) irrespective of the choice of the polynomial. Some bias-corrected estimates are negative and statistically significant for area deforested, but none of the robust estimates turn out to be statistically significant in this case. Overall, municipalities where a leftist Mayor has barely won against a non-leftist Mayor had experienced a significant annual decline in deforestation area since the past year and this holds irrespective of the choice of the polynomial or bandwidth in our sample. The size of the treatment effect tends to vary with the choice of the polynomial, linear, quadratic or cubic which is common in RD estimates. As per Table 4, the treatment effects for change in area deforested are -49.93, 85.82 and 142.6 respectively for linear, quadratic or cubic polynomials. The average value of annual change in deforested area is 17.76 square km in our

sample. In other words, the size of the treatment effect of having a leftist (as against a non-leftist) Mayor in close elections is substantial – it varies between 2.8 times the sample average for linear polynomial to 8 times of the sample average for cubic polynomial. Following Gelman and Imbens (2014), we focus on linear and quadratic polynomials because higher order polynomials increase the volatility of the estimates so that the range of the treatment effects varies between 2.8 to 4.8 times the sample average, which is a sizeable effect.

Comparison of the treatment effects of left and centre-left Mayors with left only Mayors indicates that the effect is even larger among left-only Mayors: it varies between 3-5 times of the sample average for linear and quadratic polynomials only. These effects are large and there is confirmation of our key hypothesis that election of a leftist Mayor is associated with a significant decline in area deforested since last year. Appendix Table A3 shows the deforestation estimates without any covariates (see top panel for the full sample estimates). These results are in general compatible with the estimates with covariates (see Table 4); as before the estimated effects are stronger for the annual change in area deforested. Further Table A4 shows the RD robust estimates using optimal bandwidth, which too are compatible with the baseline estimates derived by using a bandwidth of 3% as summarised in Table 4.

Effects of leftist Mayors on reforestation and environmental expenses: Full sample results

Table 5 shows the weighted robust estimates of area reforested and environmental expenses using a bandwidth of 3%.

*** Insert Table 5 here ****

As before, we consider the estimates with covariates. Considering the full sample, the treatment effects on reforestation are positive for all cases, but statistically significant only for the quadratic specification for workers' party Mayors. Given the average annual value of reforestation is 0.61 km in our sample, the estimated treatment effect is about 4.9 times the sample average for the quadratic polynomial. We get similar estimates when considering annual environmental expenses too – while close election of leftist Mayors is associated with increase in environmental expenses, the estimates are significant only for workers' party Mayors using cubic specification for the full sample. Further Table A4 confirms the validity of these results using optimal bandwidth.

Deforestation outcomes when a leftist Mayor wins/loses against right-wing one

We also re-estimated all the outcomes for the subsample where a leftist Mayor wins against a right wing candidate. While this significantly reduces the sample size, there is still confirmation of our key results (see Appendix Table A5) that the close election of a leftist Mayor still significantly reduces the rate of annual deforestation and increases reforestation as well as the environmental expenses. Evidently this effect is more pronounced when we focus on Mayors from left only parties and do not club left and centre-left parties together.

4.2.3. Effects of leftist Mayors in non-coalition governments

About 37% of sample municipality governments have been in coalition with some other parties. Presence of a coalition government may, however, obfuscate the true effects of leftist Mayors. In order to identify the true effects of leftist Mayors, we next drop the Mayors in coalition governments and focus on non-coalition Mayors only.

*** Insert Table 6 here ****

Table 6 summarises these results respectively for left and centre-left Mayors, left only Mayors and workers' party Mayors. The top panel shows the estimates of area deforested. As before, all the estimates are negative and only the bias-corrected estimates are statistically significant-none of the robust estimates are significant. The bottom panel of the table shows the corresponding estimates for the annual changes in area deforested. As in the full sample, all the robust estimates are negative and statistically significant irrespective of the measure of the left party Mayor and choice of the polynomial – linear, quadratic and cubic. Absolute size of the treatment effect of having a left party Mayor is somewhat bigger than in the full sample, which is not surprising.

*** Insert Table 7 here ****

Top panel of Table 7 shows the weighted RD robust estimates of area reforested for leftist Mayors using all three proxies for the subsample of municipal governments without any coalition. The robust estimates of area reforested are not only positive, but also statistically significant and the size of the effect is bigger relative to the full sample estimates in Table 5. As before, the observed effect is stronger for the Mayors from workers' party.

The bottom panel of Table 7 shows the corresponding estimates of environmental expenses for municipal governments without any coalition. In this case too, the estimates now turnout to be positive and statistically significant when using the quadratic and the cubic polynomials. The sample average of the variable is 641481.5 Real. So, the estimated effect of having a leftist

Mayor varies between 0.71 of the sample average to about 1.11 times the sample average. Evidently, the treatment effects are most pronounced when the Mayor belongs to the workers' party than for the left and centre-left taken together. Further Appendix Table A4 confirms the validity of these results using optimal bandwidth.

Taken together, leftist Mayors are associated with annual drop in deforested area, increase in reforested area as well as increase in total municipality expenses on environmental management in our sample; evidently, these results are stronger in non-coalition governments, as predicted.

4.2.4. Effect of Leftist Mayors in Municipalities without Budget Deficit

Some argue that municipalities may be induce to promote business interests if it needs to raise additional funds. Naturally, this would be the case if the municipality suffers from budget deficit. Nearly 8% municipalities suffer from budget deficit in our sample. So in order to understand the role of budget deficit, we obtain the weighted robust estimates of selected outcomes for municipalities without the budget deficit; we were unable to obtain the estimates for the municipalities with budget deficit because of limited observations.

*** Insert Table 8 here ****

*** Insert Table 9 here ****

Tables 8 and 9 show the weighted RD robust estimates of selected outcomes in close elections of leftist Mayors in municipalities without any budget deficit. We show estimates using linear, quadratic and cubic polynomials using bandwidth 3% for Mayors from left-only, left and centre-left and workers' parties. All regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. These estimates, outlined in Appendix Table A6 (estimates of deforested area and its annual change) and Table A7 (estimates of reforestation and environmental expenses), closely mirror the estimates for municipal governments without coalitions discussed earlier. Similar to previous findings, the most notable positive effects of leftist Mayors were observed in the annual changes in deforested areas. Mayors affiliated with workers' parties exhibited greater effectiveness in promoting reforestation and increasing environmental expenses within this subgroup.

4.3. Possible mechanisms:

Mechanism 1: Typically, municipalities governed by the left are larger in size and have a higher population, as evident in Table 2. Additionally, these municipalities tend to have a notably higher percentage of indigenous population. Table 10, Panel a, demonstrates a significant positive correlation between voter turnout and the share of votes for left only (column 1), left and centre-left (column 2) and workers' (column 3) parties. This evidence underscores the importance of accountability for leftist Mayors in meeting the needs of their constituents.

Mechanism 2: Appendix Figure A2, panel a, illustrates a strong correlation between the level of deforestation and voter turnout. Moreover, panel b of Figure A2 depicts a direct connection between the deforested area and the support for leftist (left and centre-left) candidates. This relationship is reaffirmed in Table 10, panel b estimates, indicating that voters react to deforestation by favouring leftist candidates for Mayor and hence higher vote share of leftist parties in columns 1-3. In essence, electoral democracy serves as a potential mechanism through which leftist Mayors are elected in regions with higher levels of deforestation in Brazil.

As Chief Executives of their municipalities, elected leftist Mayors can cater to their voters in various ways. They can encourage establishing internal deforestation-free policies for businesses, e.g., by implementing strict sourcing guidelines that require suppliers to prove responsible practices, enhancing corporate responsibility, and meeting consumer demands for sustainable products, thus contributing to greener and more ethical businesses. They can promote reforestation projects too by investing in initiatives that plant trees and restore degraded ecosystems, vital for combatting deforestation and its adverse impacts.

4.4. Heterogeneous impact

Our next step is to investigate additional variables that could affect the effectiveness of leftist Mayors in our sample. Specifically, we will examine the influence of factors such as a municipality's accessibility to the Trans Amazon highway, whether it is an election year, and whether the mayor is aligned/non-aligned with the President.

4.4.1. Remote versus accessible Amazon areas

Panel a of Table 11 shows the weighted RD robust estimates of change in deforested area since last year for close elections of leftist Mayors. We show the estimates of increase in deforested area since last year using linear, quadratic and cubic polynomials. Columns (1)-(3) shows

estimates for municipalities located near the highway (<=median distance) while columns (4)-(6) show those located further from the highway (>median distance). All regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality, as before.

***Insert panel a Table 11 here

Evidently, the bias-corrected robust treatment effects of having a leftist Mayor are statistically significant only when the municipalities are located above the median distance from the TransAmazon highway. These treatment effects are negative and statistically significant as before and this holds irrespective of the choice of the polynomials. The corresponding effects remain statistically insignificant when the municipality is located below median distance from the Amazon highway. In other words, the full sample results shown in Tables 3-8 appear to be driven by the remote municipalities where encroachment is difficult. The latter is likely to be explained by the fact that the leftist Mayors are more likely to be elected in indigenous land, further away from the TransAmazon highway.

4.4.2. Mayors aligned/non-aligned with the President

Panel b of Table 11 shows the weighted RD robust estimates of increase in deforested area since last year for close elections of leftist Mayors in non-aligned (columns 1-3) and aligned (columns 4-6) municipalities. In non-aligned municipalities, the Mayor and the President are not from the same party; in contrast, the Mayor and the President are from the same party in case of aligned municipalities. The underlying idea is to test whether alignment with the President weakens the leftist Mayors attitude towards tackling deforestation at the local level. For each outcome variable, we show estimates using linear, quadratic and cubic polynomials. As before, all regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality.

*** Insert panel b Table 11 here ***

In all cases the treatment effects of having a leftist Mayor are negative, but the effects are statistically more significant for cases of non-aligned Mayors in columns (1)-(3). In contrast,

for aligned mayors, the treatment effects are statistically significant in column (4) and (5), but not for column (6) using cubic polynomial. In other words, it appears that non-aligned leftist Mayors work better to reduce deforested area since last year and this holds irrespective of the choice of the polynomial – linear, quadratic or cubic. These results are compatible with the baseline results with no coalition at the local government.

4.4.3. Effect of the election year

Panel c of Table 11 shows the weighted RD robust estimates of increase in deforested area since last year for close elections of leftist Mayors in non-election (columns 1-3) and election (columns 4-6) years. For each outcome variable, we show estimates using linear, quadratic and cubic polynomials. As before, all regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year.

***Insert panel c Table 11 here ***

A comparison of the results in columns (1)-(3) with those in columns (4)-(6) shows that the effects of leftist Mayors in close elections with non-leftist Mayors are really coming from the non-election years. While the treatment effects are negative in all columns, these are statistically more significant in columns (1)-(3) irrespective of polynomial choice. Further, the size of the treatment effects for the non-election years is bigger than the overall effects that we have seen in Tables 4-6.

The obvious question is why this relationship is weaker in election years. Since the main economic challenge in Brazil is tackling inequality with an arm of poor people, the economic growth and employment are more appealing for winning votes. As such, protection of environment and indigenous well-being are not a vote winner in Brazil, especially when indigenous people represent only around 0.5% of its population.

5. Concluding comments

The article contends that in Brazil, the political left, who have traditionally advocated for the rights of workers and the impoverished, are better equipped to address deforestation and

maintain a balanced climate in the region compared to the political right, who prioritize the interests of businesses. To test this hypothesis, we analyse data from 760 municipalities in the Brazilian Amazon and investigate the impact of left-leaning mayors on various environmental outcomes such as deforested area, annual changes in deforested areas, reforested area, and annual environmental expenses of the municipality. To overcome potential issues of simultaneity between the election of a left-leaning mayor and the outcome measures in a municipality, we employ a regression discontinuity (RD) framework, using closely contested elections between left- and right-leaning candidates to randomise the election of a leftist mayor.

We used weighted RD robust estimates to investigate the relationship between the election of leftist mayors and environmental outcomes. We found that when leftist mayors were elected, there was a significant decrease in deforested areas and an increase in reforested areas, as well as an increase in annual environmental expenses. This effect was particularly pronounced when leftist mayors were in charge of government without any budget deficit and without coalitions. We observed these effects regardless of whether we considered left-only mayors, left and center-left mayors, or those from workers' parties, and regardless of the degree of polynomial used for analysis (linear, quadratic, cubic) though the effects were most pronounced for left-only Mayors. We attribute the positive effects of leftist mayors on the environment to the well-functioning electoral democracy at the local level. Leftist mayors were more likely to prioritize the needs of marginalized groups like the poor and indigenous, and the presence of electoral democracy resulted in higher voter turnout and greater left vote shares in areas with higher deforestation rates. We also found that the impact of leftist mayors was greater in municipalities that were farther from the TransAmazon highway, during non-election years, and for non-aligned mayors who were not connected with the President. The latter highlight the limits of the leftist Mayors.

The elected leftist mayors hold the capacity to ensure environmental preservation and provide targeted backing to environmental advocates. They can promote the adoption of deforestation-free policies for environmentally conscious and ethical businesses, enforce stringent sourcing criteria demanding proof of responsible practices from suppliers, elevate corporate accountability, and cater to consumer preferences for sustainable goods. Additionally, they have the ability to advocate for reforestation efforts by investing in initiatives focused on tree planting and the restoration of damaged ecosystems.

Although there has been a lot of chaos during President Bolsonaro's tenure that has resulted in the undoing of several years of good environmental policies, Brazil has the potential to become a world leader in protecting the environment due to its expanding economy and

thriving democratic system. As Bolsonaro's term concluded in 2022, there is new hope for a new Brazil that can address its environmental issues and help saving the planet too.

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Tables

Table 1. Correlations between indigenous population and the likelihood of a leftist Mayor

VARIABLES	(1) leftparty	(2) Leftparty	(3) leftonly	(4) Leftonly	(5) Workers'party	(6) Workers' party
Indig pop/10000	0.100***		0.0750***		0.0253	
	(0.0218)		(0.0212)		(0.0191)	
Share of indig pop		0.00108**		0.000847**		0.000606
		(0.000434)		(0.000421)		(0.000390)
Constant	0.236***	0.238***	0.193***	0.195***	0.164***	0.164***
	(0.00361)	(0.00364)	(0.00337)	(0.00340)	(0.00315)	(0.00317)
Observations	15,160	15,160	15,160	15,160	15,160	15,160
R-squared	0.002	0.000	0.001	0.000	0.000	0.000

Note: The table reports the likelihood of having a leftist mayor- columns (1)-(2) show the estimates of the likelihood of having a Mayor from left plus centre-left (leftparty) parties, columns (3)-(4) that of left only party and columns (5)-(6) those from workers' parties. Row (1) shows the estimate of indigenous population (as a share of 10000), row (2) shows that indigenous population as share of total municipality population. Standard errors are clustered at the municipality level; ***,**,* denote significance at the 1, 5 and 10 percent levels, respectively.

Table 1.1. Associations between elected indigenous members and the likelihood of leftist Mayor

VARIABLES	(1) leftonly	(2) leftparty	(3) Workers' party
Elected indigenous members 2016	0.0450***	0.0482***	0.0260***
	(0.00701)	(0.00755)	(0.00656)
Intercept	0.193***	0.237***	0.163***
	(0.00327)	(0.00352)	(0.00306)
Observations	15,200	15,200	15,200
R-squared	0.003	0.003	0.001

Note: The table reports the likelihood of having a leftist mayor as function of number of elected indigenous members - columns (1)-(3) respectively show the estimates of the likelihood of having a Mayor from left only, left plus centre-left and worker's party. Standard errors are clustered at the municipality level; ***,**,* denote significance at the 1, 5 and 10 percent levels, respectively.

Table 2. Comparison of municipalities governed by leftist and non-leftist Mayors

	Muni with leftist Mayor	Muni with non-leftist Mayor	T-stat
Geographic size (sq km)	7097	6533	2.1469**
Population	36099	32503	2.9015**
If poor	0.28	0.30	-1.9448*
Indigenous population	629	459	5.0921***
Indigenous population %	2.98	2.54	2.7191**
Voter turnout	10951	10290	2.7876***
Voter turnout rate	0.57	0.55	2.2568**
Mayor turnover	0.52	0.55	2.2651**
Mayor female	0.07	0.11	- 5.5084***
Mayor edu >=graduation	0.44	0.41	2.5317**
Mayor_Pres_party (align)	0.18	0.11	10.2698***
Coalition govt	0.36	0.37	-1.8367
Ln(GDP)	11.6	11.3	13.0867***
GDP per capita 2000 prices	1.46	1.30	9.1706***
Receiving oil royalty	0.068	0.018	15.8639***
ISS tax revenue	3416064	2592650	1.9714*
Total tax revenue	5447116	290430	2.3374**
Exp-revenue ratio	0.70	0.75	-10.9577***
Spending on indigenous assist.	8023	4022	1.9044*
Spending on environ management	530722	325997	2.9744***

Note: In this table leftist Mayors refer to Mayors from left and centre-left parties. These statistics are generated from our estimation sample. ***,**,* denote significance at the 1, 5 and 10 percent levels, respectively.

Table 3. First stage estimates of the likelihood of having a leftist Mayor in close elections

	Polynomial=1 coefficient	Standard error	Polynomial=2 Coefficient	Standard error	Polynomial=3 coefficient	Standard error
Bandwidth 3%						
Conventional	0.6799***	0.0829	0.5407***	0.0991	0.3953***	0.1015
Bias-corrected	0.5407***	0.0829	0.3953***	0.0991	0.2886***	0.1015
Robust	0.5407***	0.0990	0.3953***	0.1015	0.2886***	0.0969
Bandwidth 5%						
Conventional	0.76504 ***	0.06567	0.65328	0.08669	0.54407	0.09854
Bias-corrected	0.65328 ***	0.06567	0.54407	0.08669	0.4323	0.09854
Robust	0.65328 ***	0.08665	0.54407	0.09848	0.4323	0.10177
Optimal bw						
Conventional	0.5879***	0.0959	0.4974***	0.1015	0.4009***	0.1017
Bias-corrected	0.4381***	0.0959	0.3093***	0.1015	0.2133**	0.1017
Robust	0.4381***	0.1009	0.3093***	0.1018	0.2133**	0.1002

Note: All standard errors are clustered around municipality. ***,**,* denote significance at the 1,5 and 10 percent levels, respectively.

Table 4. Weighted RD robust estimates of area deforested using 3% bandwidth – full sample

Full sample	Left+centre-left			Left only			Workers		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES		Area deforested			Area deforested			Area deforested	
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Conventional	312.6	-93.85	-1,296	247.9	-442.6	-2,093	-175.8	-653.3	-1,802
	(490.1)	(929.6)	(1,762)	(548.2)	(1,066)	(2,080)	(435.6)	(894.6)	(1,778)
Bias-corrected	25.47	-949.6	-2,940*	-230.2	-1,589	-3,765*	-508.1	-1,453	-3,108*
	(490.1)	(929.6)	(1,762)	(548.2)	(1,066)	(2,080)	(435.6)	(894.6)	(1,778)
Robust	25.47	-949.6	-2,940	-230.2	-1,589	-3,765	-508.1	-1,453	-3,108
	(693.8)	(1,194)	(2,122)	(746.0)	(1,320)	(2,457)	(639.3)	(1,191)	(2,230)
Other covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,039	9,039	9,039	9,039	9,039	9,039	9,039	9,039	9,039
Panel b		Annual change in area deforested							
Conventional	-33.21**	-56.06*	-97.96*	-37.83**	-66.88**	-118.4*	-15.41	-29.06	-58.81
	(14.88)	(29.62)	(55.72)	(16.24)	(33.72)	(66.30)	(17.68)	(29.05)	(45.80)
Bias-correct	-49.93***	-85.82***	-142.6**	-58.34***	-102.7***	-167.7**	-25.01	-49.50*	-83.40*
	(14.88)	(29.62)	(55.72)	(16.24)	(33.72)	(66.30)	(17.68)	(29.05)	(45.80)
Robust	-49.93**	-85.82**	-142.6**	-58.34***	-102.7***	-167.7**	-25.01	-49.50*	-83.40*
	(20.78)	(35.07)	(58.59)	(21.99)	(39.00)	(69.45)	(20.72)	(29.98)	(46.91)
Other covs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,039	9,039	9,039	9,039	9,039	9,039	9,039	9,039	9,039

Note: The table shows the weighted RD robust estimates of deforestation outcomes: panel a shows the estimates of area deforested while panel b shows those for annual change in area deforested for leftist Mayors close elections with 3% bandwidth. For each outcome variable, we show estimates using linear, quadratic and cubic polynomials. All estimates include other covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality. ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively.

Table 5. Weighted RD robust estimates of reforestation and environmental expenses with 3% bandwidth, full sample

Full sample	Left+centre-left			Left only			Workers' party		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES		Reforestation			Reforestation			Reforestation	
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Panel a		Area reforested							
Conventional	1.046	1.834	2.784	1.369	1.956	2.836	0.646	0.887	4.012*
	(1.563)	(1.797)	(2.562)	(1.890)	(2.137)	(2.989)	(1.387)	(1.538)	(2.351)
Bias-corrected	1.574	2.500	-1.366	1.727	2.570	-1.952	0.793	2.993*	2.610
	(1.563)	(1.797)	(2.562)	(1.890)	(2.137)	(2.989)	(1.387)	(1.538)	(2.351)
Robust	1.574	2.500	-1.366	1.727	2.570	-1.952	0.793	2.993*	2.610
	(1.324)	(1.739)	(3.000)	(1.522)	(1.979)	(3.387)	(1.124)	(1.530)	(2.313)
Other covs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,039	9,039	9,039	9,039	9,039	9,039	9,039	9,039	9,039
Panel b		Annual environmental expenses							
Conventional	-138,962	-100,004	65,312	-141,467	-97,159	11,524	30,347	225,783	475,607
	(219,521)	(343,135)	(432,676)	(241,524)	(388,031)	(506,610)	(209,476)	(329,701)	(411,764)
Bias-corrected	-113,051	17,977	294,963	-112,857	-21,779	244,285	167,633	400,577	780,535*
	(219,521)	(343,135)	(432,676)	(241,524)	(388,031)	(506,610)	(209,476)	(329,701)	(411,764)
Robust	-113,051	17,977	294,963	-112,857	-21,779	244,285	167,633	400,577	780,535**
	(261,937)	(309,340)	(409,113)	(284,363)	(351,812)	(486,495)	(243,225)	(283,587)	(372,818)
Other covs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,039	9,039	9,039	9,039	9,039	9,039	9,039	9,039	9,039

Note: The table shows the weighted RD robust estimates of area reforestation annually (panel a) and also the annual environmental expenses (panel b) for close elections of leftist Mayors (various proxies) using 3% bandwidth. For each outcome variable, we show estimates using linear, quadratic and cubic polynomials. Included covariates are: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality. ***,**,* denote significance at the 1,5 and 10 percent levels, respectively.

Table 6. Weighted RD robust estimates of deforestation outcomes, leftist Mayors without coalition

No coalition	Left+centre-left			Left only			Workers' party		
Panel a	Area deforested			Area deforested			Area deforested		
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Conventional	284.4	-398.9	-1,685	211.6	-899.4	-2,804	-306.4	-1,142	-2,625
	(633.7)	(1,286)	(2,253)	(716.2)	(1,489)	(2,706)	(592.9)	(1,266)	(2,365)
Bias-corrected	-182.0	-1,621	-3,901*	-527.6	-2,570*	-5,352**	-881.5	-2,415*	-4,860**
	(633.7)	(1,286)	(2,253)	(716.2)	(1,489)	(2,706)	(592.9)	(1,266)	(2,365)
Robust	-182.0	-1,621	-3,901	-527.6	-2,570	-5,352	-881.5	-2,415	-4,860
	(954.1)	(1,742)	(2,910)	(1,025)	(1,929)	(3,386)	(887.5)	(1,678)	(2,992)
Panel b		Deforested area change			Deforested area change			Deforested area change	
Conventional	-40.07*	-81.07*	-132.1*	-46.41*	-96.20*	-162.7*	-24.31	-41.29	-73.68
	(21.56)	(44.92)	(75.70)	(23.74)	(51.88)	(92.66)	(23.00)	(37.80)	(58.52)
Bias-corrected	-68.63***	-132.3***	-210.4***	-79.92***	-158.8***	-256.4***	-35.98	-71.86*	-134.0**
	(21.56)	(44.92)	(75.70)	(23.74)	(51.88)	(92.66)	(23.00)	(37.80)	(58.52)
Robust	-68.63**	-132.3**	-210.4**	-79.92**	-158.8***	-256.4***	-35.98	-71.86*	-134.0**
	(30.82)	(53.70)	(82.35)	(32.72)	(60.02)	(99.11)	(26.45)	(38.43)	(59.80)
Other variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864

The table shows the weighted RD robust estimates of various deforestation outcomes: area deforested, increase in deforested area since last year and reforestation in close elections of leftist Mayors (various proxies). For each outcome variable, we show estimates using linear, quadratic and cubic polynomials using bandwidth 3%. All regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality. ***,**,* denote significance at the 1,5 and 10 percent levels, respectively.

Table 7. Weighted RD robust estimates of reforestation outcomes, Mayors without coalition

	Left+centre-left			Left only			Workers' party		
Panel a	Area reforested			Area reforested			Area reforested		
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Conventional	0.493	1.147	4.065*	0.894	1.620	4.946*	-0.0527	0.552	4.515*
	(0.945)	(1.494)	(2.280)	(1.118)	(1.857)	(2.758)	(1.050)	(1.565)	(2.476)
Bias-corrected	0.938	2.957**	2.284	1.369	3.659**	2.495	0.361	2.929*	3.506
	(0.945)	(1.494)	(2.280)	(1.118)	(1.857)	(2.758)	(1.050)	(1.565)	(2.476)
Robust	0.938	2.957*	2.284	1.369	3.659**	2.495	0.361	2.929*	3.506*
	(1.105)	(1.610)	(2.274)	(1.309)	(1.807)	(2.729)	(1.122)	(1.680)	(2.050)
Other variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864
Panel b	Left+centre-left			Left only			Workers		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Annual environmental expenses			Annual environmental expenses			Annual environmental expenses		
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Conventional	68,334	275,714	538,626	113,629	384,671	666,491	261,379*	531,452**	747,048**
	(162,615)	(258,228)	(366,269)	(189,004)	(305,301)	(449,160)	(154,886)	(235,643)	(369,951)
Bias-corrected	211,454	458,530*	608,012*	294,693	577,587*	696,755	448,609***	665,069***	715,893*
	(162,615)	(258,228)	(366,269)	(189,004)	(305,301)	(449,160)	(154,886)	(235,643)	(369,951)
Robust	211,454	458,530*	608,012*	294,693	577,587**	696,755	448,609***	665,069***	715,893*
	(193,410)	(244,203)	(353,356)	(217,488)	(288,178)	(432,038)	(159,616)	(223,736)	(388,771)
Other covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864	6,864

The table shows the weighted RD robust estimates area reforested (panel a) and environmental expenses (panel b) in close elections of leftist Mayors (various proxies). For each outcome variable, we show estimates using linear, quadratic and cubic polynomials using bandwidth 3%. All regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality. ***,**,* denote significance at the 1,5 and 10 percent levels, respectively.

Table 8. Effects of non-coalition leftist Mayors on deforestation in municipalities without any budget deficit

	Left plus centre-left			Left only			Workers' party		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES		Area deforested			Area deforested			Area deforested	
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Conventional	241.8	-556.1	-2,589	148.9	-1,075	-3,906	-314.3	-1,250	-3,513
	(678.7)	(1,377)	(2,757)	(759.3)	(1,577)	(3,298)	(671.0)	(1,425)	(2,976)
Bias-corrected	-326.3	-1,979	-5,447**	-692.9	-2,991*	-7,082**	-960.7	-2,705*	-6,314**
	(678.7)	(1,377)	(2,757)	(759.3)	(1,577)	(3,298)	(671.0)	(1,425)	(2,976)
Robust	-326.3	-1,979	-5,447	-692.9	-2,991	-7,082*	-960.7	-2,705	-6,314*
	(1,028)	(1,845)	(3,457)	(1,091)	(2,017)	(4,027)	(991.9)	(1,864)	(3,680)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,212	6,212	6,212	6,212	6,212	6,212	6,212	6,212	6,212
VARIABLES		Annual change in deforestation			Annual change in deforestation			Annual change in deforestation	
Conventional	-38.14	-79.51	-156.8*	-43.92*	-93.82*	-193.3*	-14.57	-25.81	-73.62
	(24.33)	(49.35)	(95.00)	(26.30)	(55.59)	(115.2)	(25.52)	(39.62)	(62.76)
Bias-corrected	-68.03***	-133.5***	-237.9**	-78.63***	-161.1***	-289.8**	-22.26	-56.58	-137.2**
	(24.33)	(49.35)	(95.00)	(26.30)	(55.59)	(115.2)	(25.52)	(39.62)	(62.76)
Robust	-68.03*	-133.5**	-237.9**	-78.63**	-161.1**	-289.8**	-22.26	-56.58	-137.2**
	(35.18)	(59.51)	(101.4)	(36.73)	(65.06)	(121.9)	(28.22)	(38.01)	(60.88)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,212	6,212	6,212	6,212	6,212	6,212	6,212	6,212	6,212

Note: The table shows the weighted RD robust estimates of deforested area and annual change in deforested area in close elections of leftist Mayors in municipalities without any revenue deficit. We show estimates using linear, quadratic and cubic polynomials using bandwidth 3%. All regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality. ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively.

Table 9. Effects of non-coalition leftist Mayors on reforestation and environmental expenses in municipalities without any budget deficit

	Left plus centre-left			Left only			Workers' party		
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
VARIABLES		Reforested area			Reforested area			Reforested area	
Conventional	0.504	1.131	3.890	0.952	1.713	4.892	0.121	0.859	5.021*
	(0.979)	(1.581)	(2.562)	(1.146)	(1.965)	(3.099)	(1.157)	(1.741)	(2.951)
Bias-corrected	0.942	3.000*	1.089	1.460	3.868**	1.527	0.625	3.496**	3.368
	(0.979)	(1.581)	(2.562)	(1.146)	(1.965)	(3.099)	(1.157)	(1.741)	(2.951)
Robust	0.942	3.000*	1.089	1.460	3.868**	1.527	0.625	3.496*	3.368
	(1.188)	(1.711)	(2.401)	(1.401)	(1.910)	(3.016)	(1.241)	(1.876)	(2.395)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,212	6,212	6,212	6,212	6,212	6,212	6,212	6,212	6,212
VARIABLES		Environomnetal exp			Environomnetal exp			Environomnetal exp	
Conventional	48,203	240,214	474,589	91,623	349,664	614,184	301,307*	609,370**	838,978**
	(174,798)	(274,939)	(385,114)	(200,436)	(319,482)	(467,457)	(175,530)	(267,295)	(418,743)
Bias-corrected	184,839	403,519	557,655	268,531	528,692*	656,538	515,386***	756,029***	793,729*
	(174,798)	(274,939)	(385,114)	(200,436)	(319,482)	(467,457)	(175,530)	(267,295)	(418,743)
Robust	184,839	403,519	557,655	268,531	528,692*	656,538	515,386***	756,029***	793,729*
	(210,544)	(262,872)	(379,865)	(233,918)	(304,461)	(461,408)	(180,003)	(255,820)	(446,584)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,212	6,212	6,212	6,212	6,212	6,212	6,212	6,212	6,212

Note: The table shows the weighted RD robust estimates of reforested area and environmental expenses in close elections of leftist Mayors in municipalities without any revenue deficit. We show estimates using linear, quadratic and cubic polynomials using 3% bandwidth. All regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality. ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively.

Table 10. Mechanisms

Mechanism 1	(1)	(2)	(3)
VARIABLES	voteshare_left	voteshare_leftonly	voteshare_workers
ln(turnout)	0.0581***	0.0521***	0.128***
	(0.00722)	(0.00449)	(0.0185)
Year dummies	Yes	Yes	Yes
Observations	13,804	14,188	14,188
R-squared	0.028	0.036	0.084
Mechanism 2	(1)	(2)	(3)
VARIABLES	voteshare_left	voteshare_leftonly	voteshare_workers
ln(Deforested)	0.00467***	0.00427***	0.00628***
	(0.00177)	(0.00159)	(0.00230)
Year dummies	Yes	Yes	Yes
Observations	14,312	14,188	14,188
R-squared	0.025	0.029	0.051

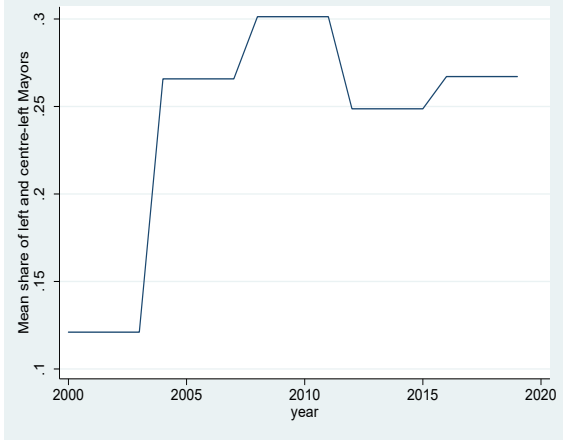
Note: Columns (1)-(3) show the estimates of ln(turnout) on leftist Mayors while columns (4)-(6) show those on leftist vote shares. Leftparty is a binary variable indicating if the Mayor is from left or centre-left parties; leftonly is a binary variable indicating if the Mayor is from left parties only while worker's party is another binary variable indicating if the Mayor is from the workers' parties. All standard errors are clustered around municipality. ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively.

Table 11. Heterogenous impact of leftist Mayors on change in deforested area

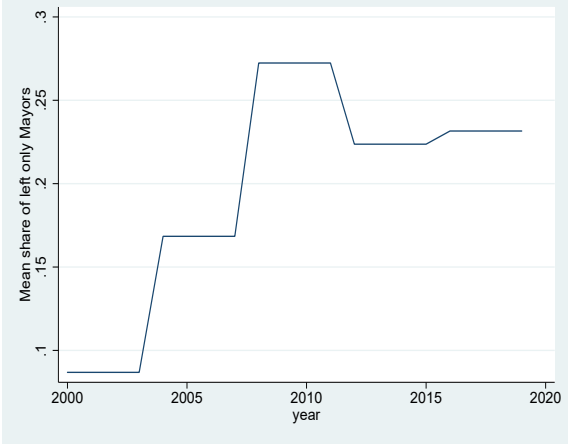
Panel a	**<= median distance to highway**			**Above median distance to highway**		
	(1)	(2)	(3)	(4)	(5)	(6)
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Robust	-23.547	-31.373	-44.151	-50.357 **	-98.39***	-182.26 **
	(25.241)	(32.548)	(38.551)	(22.057)	(36.751)	(70.763)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4504	4504	4504	4535	4535	4535
Panel b	**Non-aligned**			**Aligned**		
Robust	-207.6**	-112.0**	-56.05**	-53.16***	-41.81*	-39.08
	(88.31)	(47.86)	(27.16)	(20.63)	(23.77)	(26.58)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,026	8,026	8,026	1,013	1,013	1,013
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Panel c	**Non-election year**			**Election year**		
	(1)	(2)	(3)	(4)	(5)	(6)
Robust	-73.09**	-116.4**	-165.1**	15.08	5.933	-34.87
	(28.38)	(47.72)	(70.45)	(14.83)	(24.20)	(42.44)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,591	6,591	6,591	2,448	2,448	2,448

The table shows the weighted RD robust estimates of change in deforested area since last year for close elections of leftist Mayors, using linear, quadratic and cubic polynomials. Panel a shows the estimates by distance to the TransAmazon highway, panel b shows those where Mayor's party is aligned/non-aligned with the President while panel c shows those for non-election/election years. Columns (1)-(3) in panel a shows estimates for municipalities located near the highway (<=median distance) while columns (4)-(6) show those located further from the highway (>median distance). Columns (1)-(3) of Panel b shows estimates for leftist Mayors aligned with the President while columns (4)-(6) shows those for non-aligned leftist Mayors. Columns (1)-(3) of Panel c shows estimates for non-election years while columns (4)-(6) show those for election years. All estimates use bandwidth 3%. All regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality. ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively.

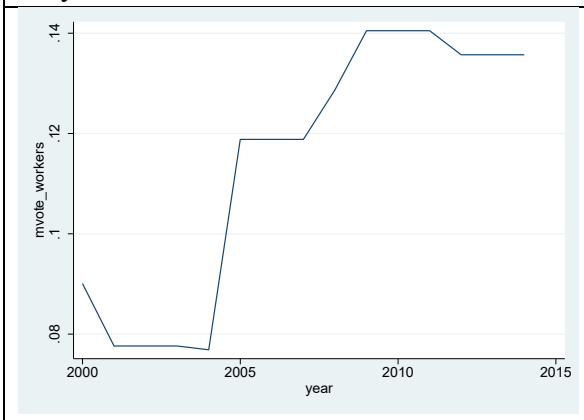
Figure 1. Trend in the share of left-leaning Mayors



a. Trend in mean share of left & centre-left Mayors

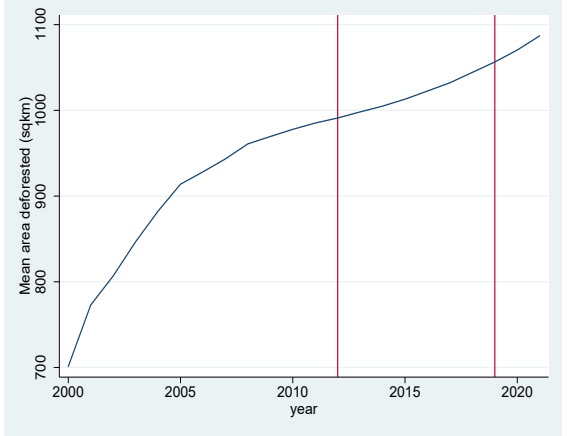


b. Trend in mean share of left only Mayors

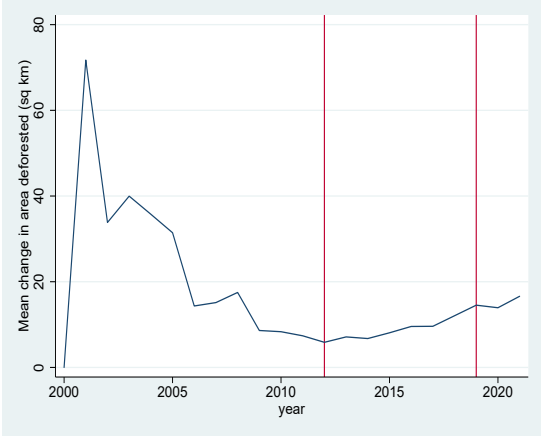


c. Trend in mean share of workers' party Mayors

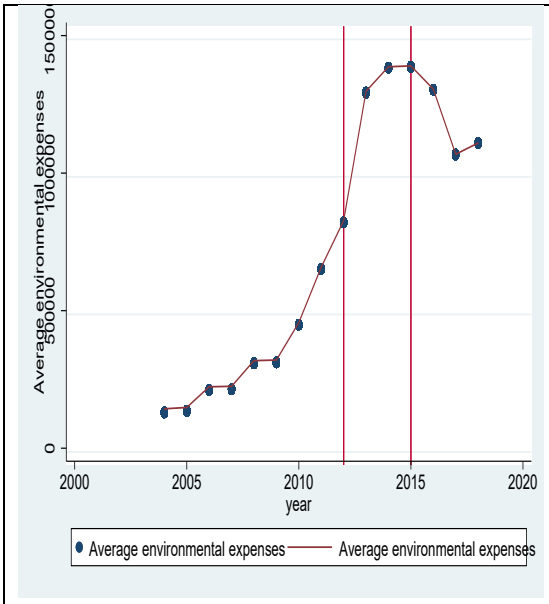
Figure 2. Trends in deforested area, change in deforested areas and environmental expenses in the Brazilian Amazon



a. Trend in deforestation in the sample



b. Trend in change in deforestation



c. Trend in environmental expenses

Figure 3a. RD plot of deforestation/reforestation outcomes – left plus centre-left Mayors

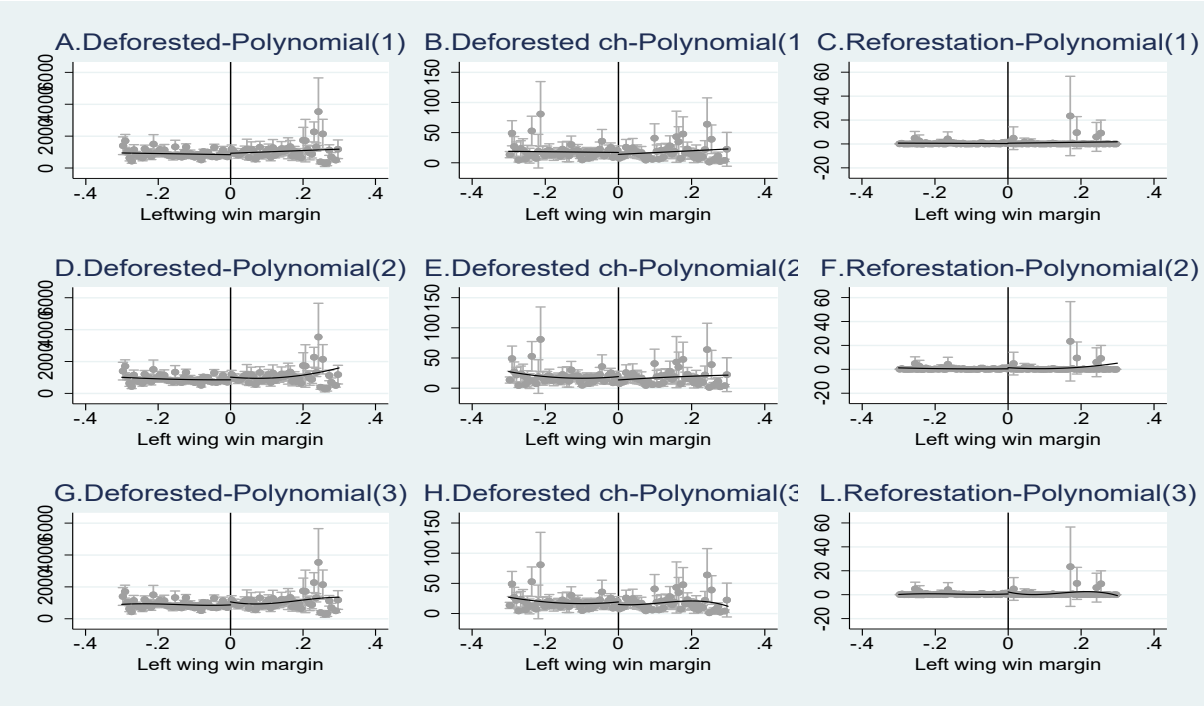


Figure 3b. RD plot of deforestation/reforestation outcomes – left only Mayors

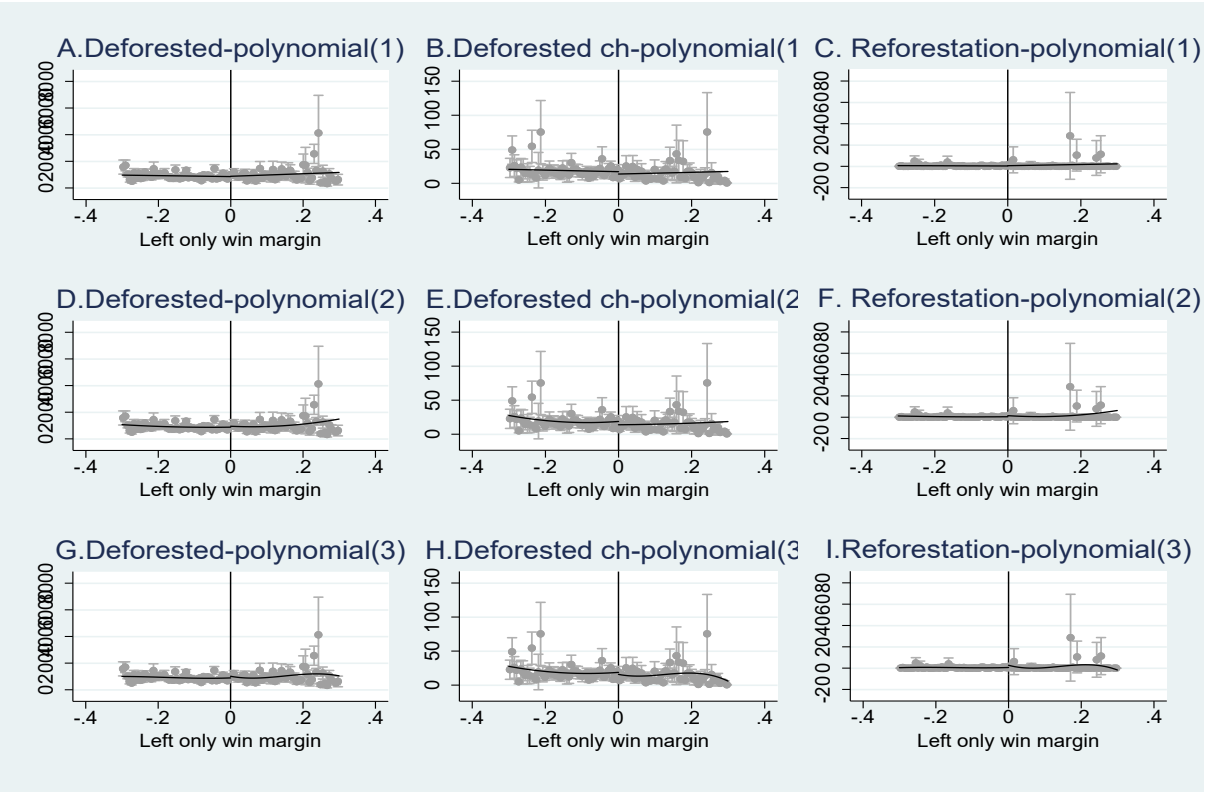


Figure 3c. RD plot of natural logarithm of environmental expenses

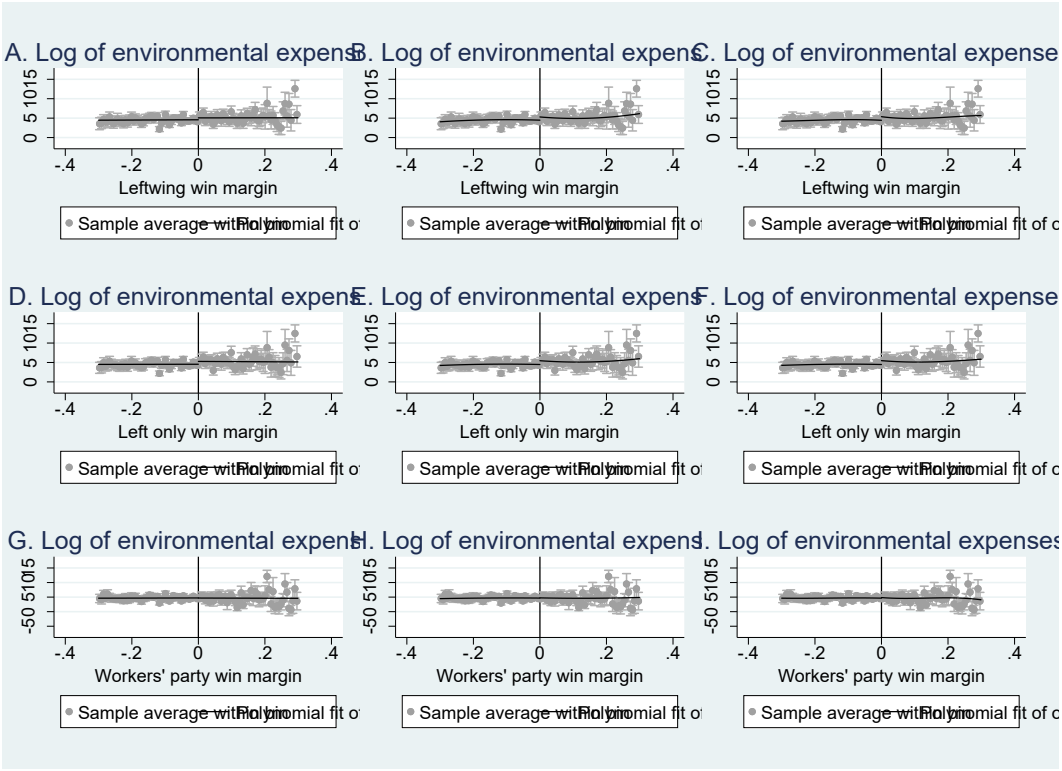


Figure 4. Distribution of leftist Mayoral winning margin

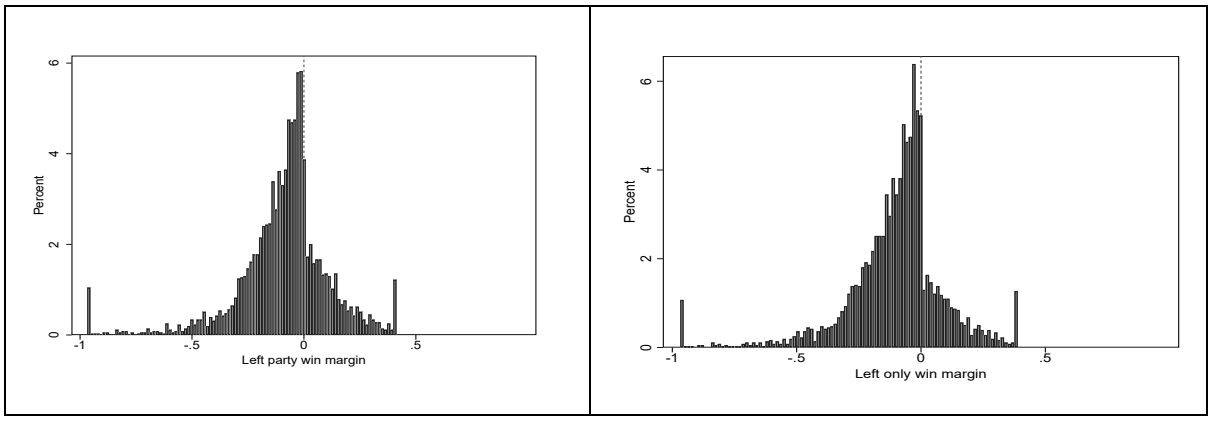


Figure 5. Political fragmentation and win margin

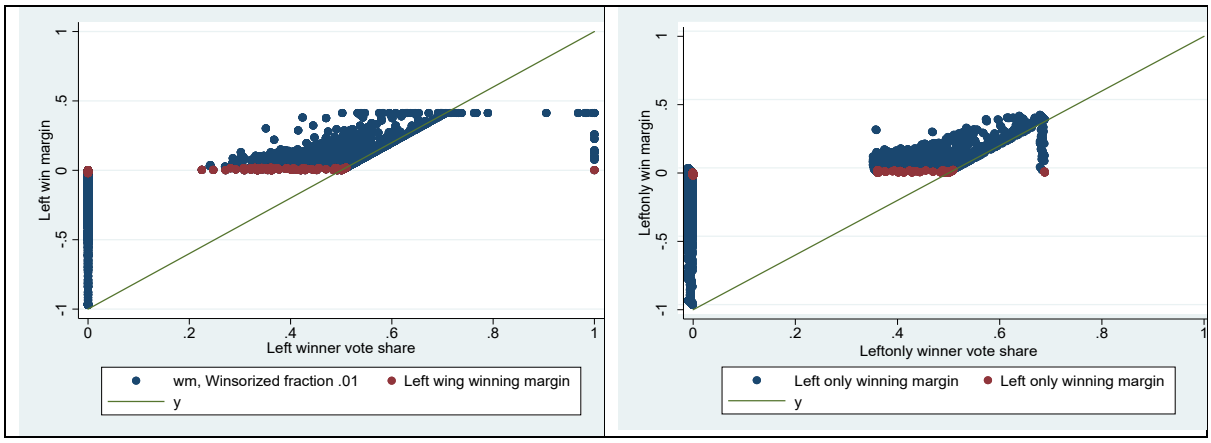
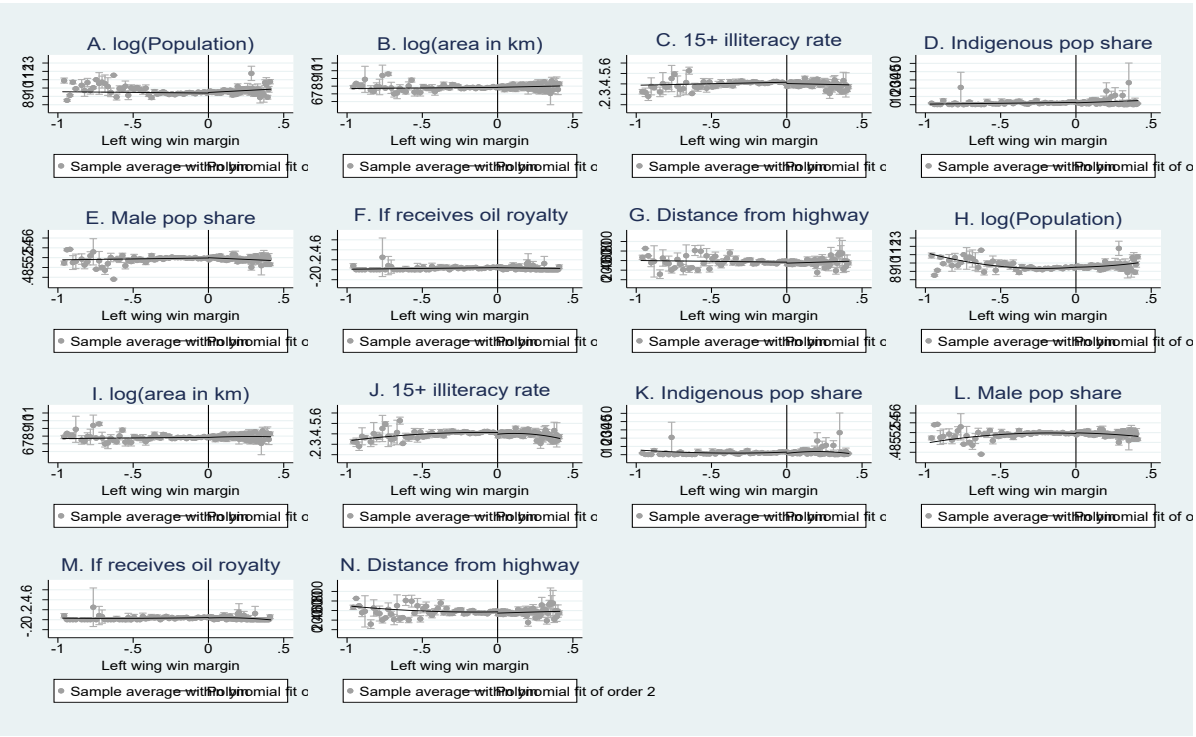


Figure 6. Balancing of the covariates around the cut-off



Appendix

Table A1. Data sources

Variables	Source	Method
TransAmazon Highway (BR-230)	DNIT - Infrastructure - https://www.gov.br/infraestrutura/pt-br/assuntos/dados-de-transportes/bit/bitmodosmapas#maprodo	Distance Tool between nearest point distance from centroi
Dams	ANA - Water Agency - https://www.ana.gov.br/exporta-planilha/snisb/relatorio_barragens.csv	Join of points from dams report w Municipalit
Blacklist	MMA - Ministry of the Environment - https://www.gov.br/mma/pt-br/assuntos/servicosambientais/controle-de-desmatamento-e-incendios-florestais/pdf/Listagemmunicpiosprioritriosparaaesdepreveno2021.pdf	
Elections	TSE - Superior Electoral Court - https://www.tse.jus.br/hotsites/pesquisas-eleitorais/resultados_anos/2018.html and https://www.tse.jus.br/eleicoes/eleicoes-anteriores/eleicoes-1998/candidaturas-votacao-e-resultados/resultado-da-eleicao-de-1998	
Homicides	IPEA - Institute of Applied Economic Research - https://www.ipea.gov.br/atlasviolencia/filtros-series/1/homicidios	
Other crime indices	SUS - National Health Service - http://www2.datasus.gov.br/DATASUS/index.php?area=0205&id=1878964	
Conflict with indigenous people	CPT - Pastoral Land Comission - https://www.cptnacional.org.br/downlods/category/4-areas-em-conflito	
Infectious disease	SUS - National Health Service - http://www2.datasus.gov.br/DATASUS/index.php?area=0203&id=29892332&VObj=http://tabnet.datasus.gov.br/cgi/deftohtm.exe?sinannet/cnv/viole	
Municipality finances	Tesouro Transparente - Transparency National Treasure - https://www.tesourotransparente.gov.br/publicacoes/finbra-dados-contabeis-dos-municipios-1989-a-2012/2001/26 - Data between 2000 and 2012 https://www.tesourotransparente.gov.br/consultas/consultas-siconfi/siconfi-finbra-demonstrativos-de-contas-anuais - Data between 2013 and 2018	
Demographics	Census 2000 & 2010	

Table A2: Summary statistics of key regression variables

Variable	Obs	Mean	Std. Dev.
Area Deforested (sq km)	15,200	942.4842	1347.288
Deforested change (sq km)	15,200	17.7649	67.09414
Area reforested (sq km)	`12160	0.7625	13.0048
Environmental expenses (Real)	15,200	641481.5	4418154
Winning margin	14,148	-0.0874255	0.2058052
Leftparty (left & centre-left)	15,200	0.2407895	0.4275768
Leftonly (left only)	15,200	0.1965789	0.3974243
Workers' party	15200	0.1654605	0.3716079
Indigenous elected in 2016	3040	0.0460526	0.209606
Ln(population)	13,433	9.536831	1.102628
Ln(Size)	15,200	7.830709	1.355557
15+ illiterate rate	10,516	0.4077388	0.0877455
Indigenous pop share	15,160	2.644885	8.719648
Male pop share	15,179	0.5178572	0.0150216
Poor pop share	15,200	0.2947368	0.4559394
If has oil royalty	15,200	0.0373684	0.1896692
Distance from TransAmazon highway	14,440	368.6225	258.1701

Table A3. RD robust estimates of deforestation outcomes without any covariates

	(1)	(2)	(3)	(4)	(5)	(6)
Full sample	deforested	deforested	Deforested	deforested_change	deforested_change	deforested_change
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Conventional	249.0	-300.5	-1,284	-22.73**	-39.35**	-57.29*
	(450.0)	(747.6)	(1,293)	(8.990)	(17.03)	(30.06)
Bias-corrected	-188.1	-1,019	-2,294*	-35.95***	-52.47***	-72.81**
	(450.0)	(747.6)	(1,293)	(8.990)	(17.03)	(30.06)
Robust	-188.1	-1,019	-2,294	-35.95***	-52.47**	-72.81**
	(584.0)	(913.8)	(1,558)	(12.71)	(20.61)	(32.61)
Covariates	No	No	No	No	No	No
Observations	14,148	14,148	14,148	14,148	14,148	14,148
No coalition						
Conventional	-149.3	-1,376	-3,543	-38.87**	-75.34**	-124.5**
	(717.8)	(1,311)	(2,404)	(16.19)	(32.70)	(61.04)
Bias-corrected	-1,109	-2,976**	-6,166**	-67.41***	-111.6***	-173.4***
	(717.8)	(1,311)	(2,404)	(16.19)	(32.70)	(61.04)
Robust	-1,109	-2,976*	-6,166**	-67.41***	-111.6***	-173.4***
	(959.7)	(1,602)	(2,929)	(22.56)	(39.24)	(66.20)
Covariates	No	No	No	No	No	No
Observations	8,712	8,712	8,712	8,712	8,712	8,712

Note: The table shows the weighted RD robust estimates of deforested area and annual change in deforested area in close elections of leftist Mayors in municipalities without any covariates. We show estimates using linear, quadratic and cubic polynomials using 3% bandwidth. The top panel shows the full sample results while the bottom panel shows those for no coalitions. All standard errors are clustered around municipality. ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively.

Table A4. RD robust estimates using Optimal bandwidth

Panel a. Full sample	Left+centre-left			Left only		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	deforested			deforested_change		
Polynomial	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Robust	44.39	-783.1	-2,592	-42.53**	-73.16**	-123.4**
	(712.0)	(1,168)	(2,020)	(20.24)	(33.58)	(54.18)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,039	9,039	9,039	9,039	9,039	9,039
VARIABLES	reforest			envexp_total		
Robust	1.708*	2.536	-1.546	-85,050	56,113	326,044
	(0.970)	(1.641)	(3.036)	(256,665)	(305,012)	(386,429)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,039	9,039	9,039	9,039	9,039	9,039
Panel b. No coalition	Left+centre-left			Left only		
VARIABLES		deforested			deforested_change	
Robust	-200.8	-1,434	-4,117	-61.84**	-116.0**	-209.6**
	(947.0)	(1,646)	(2,983)	(29.62)	(50.64)	(84.42)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,864	6,864	6,864	6,864	6,864	6,864
VARIABLES		reforest			envexp_total	
Robust	1.113	3.313**	2.570	198,586	458,963*	644,747*
	(1.121)	(1.549)	(2.358)	(190,087)	(244,257)	(341,396)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,864	6,864	6,864	6,864	6,864	6,864

Note: The table shows the weighted RD robust estimates of all outcome variables in close elections of leftist Mayors in municipalities without covariates. We show estimates using linear, quadratic and cubic polynomials and optimal bandwidth. Panel a shows the full sample results while the panel b shows those for no coalitions. All regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality. ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively.

Table A5. Estimates of deforestation outcomes when leftist Mayors win against right-wing ones and vice versa

Left only Mayors winning against right candidates								
Polynomials:	p1	p2	p1	p2	p1	p2	p1	p2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	deforested	deforested	deforested_change	deforested_change	reforest	reforest	lenvexp	lenvexp
Conventional	-710.8	-901.7	-17.39**	-14.83	-5.979	-21.09	6.331**	10.45
	(557.1)	(827.1)	(6.831)	(9.974)	(9.945)	(14.49)	(2.929)	(6.452)
Bias-corrected	-854.1	-1,198	-16.30**	-13.87	-15.65	-28.84**	8.958***	15.13**
	(557.1)	(827.1)	(6.831)	(9.974)	(9.945)	(14.49)	(2.929)	(6.452)
Robust	-854.1	-1,198*	-16.30**	-13.87	15.65	28.84**	8.958***	15.13***
	(549.3)	(712.4)	(7.564)	(10.33)	(11.43)	(13.15)	(3.283)	(5.750)
Observations	248	248	248	248	248	248	248	248
Left plus centre left Mayors winning against right-wing candidates								
	p1	p2	p1	p2	p1	p2	p1	p2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	deforested	deforested	deforested_change	deforested_change	reforest	reforest	lenvexp	lenvexp
Conventional	-92.48	-150.5	-11.94*	-1.214	-0.338	-2.523	1.704	2.982
	(377.1)	(541.4)	(6.104)	(7.927)	(3.372)	(3.747)	(1.479)	(2.429)
Bias-corrected	-142.6	-306.3	-4.084	5.952	-2.212	-0.129	2.684*	4.012*
	(377.1)	(541.4)	(6.104)	(7.927)	(3.372)	(3.747)	(1.479)	(2.429)
Robust	-142.6	-306.3	-4.084	5.952	-2.212	-0.129	2.684	4.012
	(463.2)	(576.7)	(7.677)	(10.28)	(3.317)	(4.898)	(1.910)	(2.822)
Observations	494	494	494	494	494	494	494	494

Note: The table shows the weighted RD robust estimates of all outcome variables, area deforested in columns 1-2, annual change in area deforested in columns 3-4, area reforested in columns 5-6 and ln(environmental expenses) in columns 7-8 in close elections of leftist Mayors winning against right-wing ones and vice-versa. We show estimates using linear and quadratic polynomials and bandwidth 3%. Panel a shows the estimates for left only Mayors while the panel b shows those for left and centre left Mayors. All regressions include covariates: population size, geographic area, 15+ illiteracy rate, indigenous population share, male population share if it is a protected indigenous land, distance from nearest highway, if receives oil royalty share and if it is an election year. All standard errors are clustered around municipality and shown in parentheses. ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively.

Figure A1. RD plot of outcomes – Workers' party Mayors

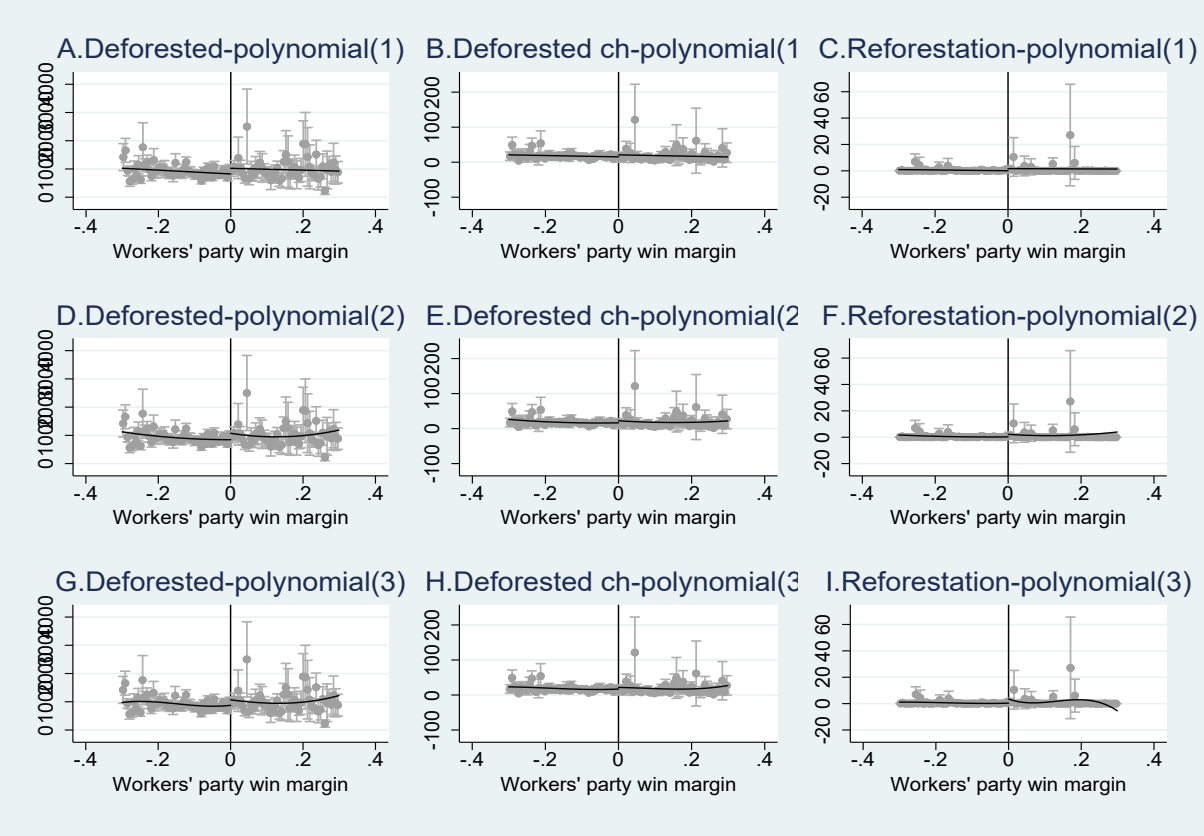
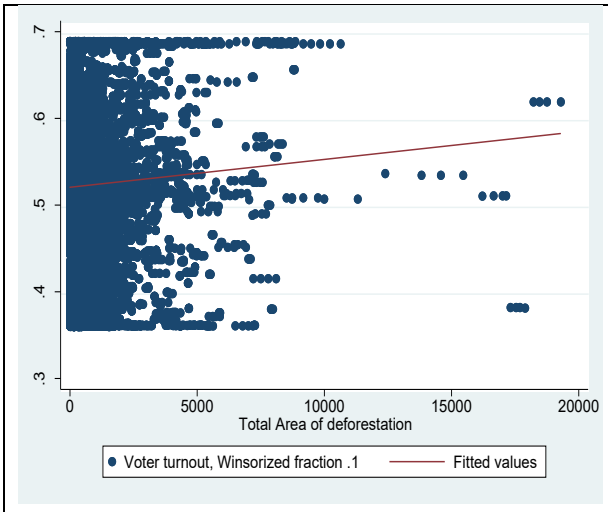
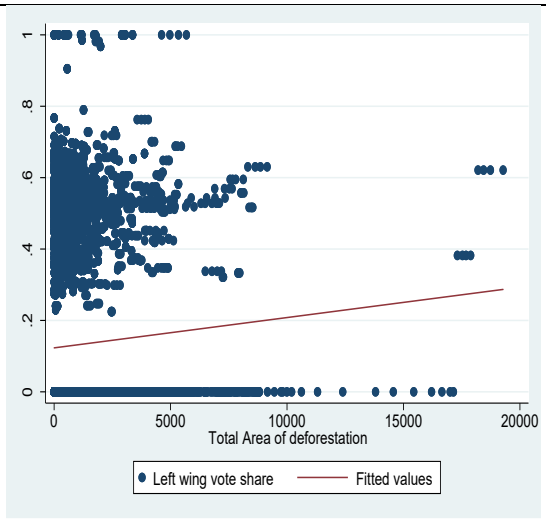


Figure A2. Deforestation, voter turnout and leftist vote share



Panel a: Deforestation and voter turnout



Panel b: Deforestation and left vote share

Appendix B. Classification of party ideology

					Party ideology	
Party Anacronym	***Full Name***	***Originated from previous party***	***Year of creation/Year of official registration***	***Details***	***BBC Brasil***	***Bolognesi et al. 2021***
PL	Partido Liberal		2005/2006	2006	Right	NC
PATRIOTA	Patriota		2011/2012	2012	Right	Extreme-Right
PODE	Podemos	Partido Trabalhista Nacional (PTN)	1995/1995	1995	Right	Right
PP	Progressistas	Partido Progressista (PP)	2017/2017	Changes in the party name: Partido Progressista Brasileiro (PPB) 1995–2003; Partido Progressista (PP) 2003–2017; and Progressistas (PP) 2017–present	Right	Extreme-Right
PRTB	Partido Renovador Trabalhista Brasileiro		1990/1997		Right	Right
PSC	Partido Social Cristão		1985/1990		From Right to Extreme Right	Right
PTB	Partido Trabalhista Brasileiro		1979/1981	It incorporated PSD (Partido Social Democrático) in 2002 and PAN (Partido dos Aposentados da Nação) in 2007.	From Right to Extreme-Right	Centre-Right
PTC	Partido Trabalhista Cristão		1989/1989		Right	Right

DEM	Democratas	PFL (Partido da Frente Liberal). Changed its name to DEM in 2007.	1985/1986	In 2021 DEM split and generated PDS (Partido Democrático Social) and UB (União Brasil) joint to PSL (Partido Social Liberal)	Centre-Right	Extreme-Right
Republicanos	Republicanos	Partido Municipalista Renovador (PMR)	2003/2005	Partido Municipalista Renovador (PMR) had its name changed to Partido Republicano Brasileiro (PRB) in 2005 and to Republicanos in 2019	From Centre-Right to Right	NC
PPB (also PP)	Partido Progressista Brasileiro		1995/1995	In 2003 it was extinct to generate Partido Progressista (PP)	Right	Extreme-Right
PR	Partido Liberal	Partido de Reedificação da Ordem Nacional (PRONA) and Partido Liberal (PL)	2006/2006	It was generated by the merger of PRONA and PL	From Right to Extreme Right	Right
PRB	Partido Republicano Brasileiro	Partido Municipalista Renovador (PMR)	2005/2005	In 2019 had its name changed to Republicanos (Republicanos)	From Centre-Right to Right	Right
PSL	Partido Social Liberal		1994/1998	Extinct in 2022. Bolsonaro was elected in 2019 by this party	From Right to Extreme Right	Right
PSDB	Partido da Social Democracia Brasileira	-	1988/1989	Created from a dissidence from the Partido do Movimento Democrático Brasileiro (PMDB)	From Centre to Centre-Right	Right
PMB	Partido da Mulher Brasileira		2008/2015	It was renamed to Brasil 35 in 2021	Centre-Right	Right
PSD	Partido Social Democrático	-	2011/2011		Centre	Right
DC	Democracia Cristã	-	1995/1997	Party connected to religion	From Centre to Centre-Right	Right

PRP	Partido Republicano Progressista	-	1989/1991	Party finished in 2019	Centre-Right	Right
PT	Partido dos Trabalhadores	-	1980/1982	Party of the former president Lula	From Centre-Left to Left	Left
PCB	Partido Comunista Brasileiro	-	1993/1996		Extreme-Left	Extreme-Left
PC do B	Partido Comunista do Brasil	Created from Partido Comunista (PC) dissidents	1962-1988		From Centre-Left to Left	Left
PCO	Partido da Causa Operária	Created from Partido dos Trabalhadores (PT) dissidents	1995/1997		Extreme-Left	Extreme-Left
PDT	Partido Democrático Trabalhista		1979/1981		From Centre-Left to Left	Centre-Left
PMN	Partido da Mobilização Nacional		1984/1990		Centre-Left	Centre-Right
PSB	Partido Socialista Brasileiro		1985/1988		Centre-Left	Centre-Left
PSOL	Partido Socialismo e Liberdade	Created from Partido dos Trabalhadores (PT) dissidents	2004/2005		From Left to Extreme-Left	Left
PSTU	Partido Socialista dos Trabalhadores Unificado	Created from Partido dos Trabalhadores (PT) dissidents	1994/1995		Extreme-Left	Extreme-Left
PV	Partido Verde		1986/1993		Centre-Left	Centre-Left
AVANTE	Avante	Created from Partido Trabalhista Brasileiro (PTB) dissidents	1989/2004	The original name of the party was Partido Trabalhista do Brasil (PTdoB). Changed to AVANTE in 2017	Centre-Left	Centre-Left
CIDADANIA (also PPS)	Cidadania		1992/1992	Initital name was Partido Popular Socialista (PPS), changed to Cidadania in 2019	Centre-Left	Centre-Left
PROS	Partido Republicano da Ordem Social		2010/2013		Centre-Left	NC
SOLIDARIEDADE (also SDD)	Solidariedade		2012/2013		Centre-Left	Right

PPS (also CIDADANIA)	Partido Popular Socialista		1992/1992	Former name of the current Cidadania	Centre-Left	Centre-Left
REDE	Rede Sustentabilidade		2013/2015	Marina Silva is the founder	From Centre-Left to Centre-Right	Centre-Left
PMDB	Partido do Movimento Democrático Brasileiro	Partido do Movimento Democrático Brasileiro (PMDB) of 1966-1979	1980/1981	Changed its name to MDB in 2017	Centre	NC
MDB	Movimento Democrático Brasileiro	Partido Movimento Democrático Brasileiro (PMDB of 1980-2017)	1980/1981	Named PMDB until 2017	Centre	Centre-Left
PTB	Partido Trabalhista Brasileiro		1979/1981	It incorporated PSD (Partido Social Democrático) in 2002 and PAN (Partido dos Aposentados da Nação) in 2007.	From Right to Extreme-Right	Centre-Left

Note: NC stands for no classification. Source: BBC Brasil and Bolognesi et al. (2021)