Natural disasters support authoritarian populism: Evidence from the Brazilian shrimp vote*

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Abstract

This research paper investigates the relationship between natural disasters and protests against autocratic regimes using data from the 1979-1983 Drought in the Brazilian semi-arid region. The study utilizes data from meteorological stations to compute deviations from historical means of water deficit and uses it as the primary explanatory variable. The results suggest a negative causal effect of adverse weather conditions on protests against the military regime. Additionally, the study finds that disaster relief provided by the government, income inequality, and social vulnerability measures do not seem to drive this effect. However, the effect is heterogeneous to the degree of economic vulnerability, as measured by the importance of cotton for local production, suggesting that this may be the relevant mechanism at play. The study also puts forth a probabilistic voting model that reconciles mixed findings in the literature and guides the empirical exercise.

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1 Introduction

In recent years, the world has seen a growing trend of authoritarian regimes undermining democratic institutions. At the same time, new studies on climate change have revealed that natural disasters are becoming more frequent and severe (IPCC, 2021). In this paper, we explore the relationship between natural disasters and authoritarian rule. Our research finds that natural disasters can actually help authoritarian leaders to maintain power by reducing the number of protest votes against the government. Using the example of the 1982 Brazilian elections, we show that regions affected by adverse weather conditions had a lower rate of protest votes against the military dictatorship in power.

The 1982 Brazilian general elections provide a unique opportunity to study the impact of natural disasters on support for democracy. The semi-arid region of the country was suffering from a prolonged drought that began in 1979, which created a challenging environment for the population. Additionally, the political context of the time allows for a clear measure of support for the authoritarian ruling party, known as the "shrimp vote." This type of vote was a strategy used by voters who supported local candidates affiliated with the military party but wanted to distance themselves from the authoritarian central government. Therefore, municipalities with a higher percentage of shrimp votes were those where voters were more likely to protest against the dictatorship. The 1982 general elections also stand out as a rare instance in which local, state, and federal officials were elected simultaneously, which enables us to estimate the effects on gubernatorial elections based on local preferences.

Our measure of protest is based on a combination of democratic institutions under authoritarian control promoted by the military regime. In 1982, the regime allowed for general elections, which included the election of state governors for the first time since the dictatorship began in 1964. However, a crucial electoral rule was introduced to prevent a defeat at the polls: voters were only allowed to vote for the same party for all positions. This strategy was intended to ensure that local support for candidates affiliated with the military party would also result in victories at state-level elections.[1] However, this strategy backfired as many local politicians used

[1]It is important to note that the military party controlled many of the municipal executive branches in small and rural cities. The aim of this strategy was to automatically translate local support into national backing. We provide more information on this in Section 2.

the shrimp vote as a way to protest against the central government while maintaining their local alliances. Therefore, our measure of protest is based on the difference in vote share for military party candidates for mayor and governor in a given municipality. Given the electoral rules implemented by the regime, this difference should be zero unless voters cast shrimp votes as a form of protest.

The shrimp vote was particularly important for voters in the Brazilian semi-arid region due to its historical support for conservative parties. Additionally, the area was disproportionately affected by one of its most prolonged droughts, lasting from 1979 to 1983. These two characteristics make the semi-arid region an ideal laboratory for studying the effects of adverse natural disasters on support for authoritarianism. Our central assumption is that, when controlling for state fixed effects and the history of water deficit, drought severity is not correlated with any other local factors that determine political preferences for authoritarian regimes. This assumption is supported by a balance test and the remarkable stability of our estimates when controlling for several geographical, electoral, and socioeconomic covariates in our models.

Our research findings suggest that drought severity can have a significant impact on voter behavior, particularly in terms of reducing the inclination to protest against the military regime. Specifically, a median increase in drought severity decreases the proportion of protest votes against the authoritarian regime by 14.6% of the mean, and an increase equivalent to the 90^{th} percentile decreases it by 38.4% of the mean. In practical terms, this means that in a typical municipality with a population of 6,000, there would be 84 (or 184 in extreme scenarios) more people likely to participate in pro-democracy demonstrations if it were not for the drought.

Although our unique study setting does not allow for controlling for time-invariant unobservables, we include pre-treatment characteristics in our model specification to avoid any spurious correlation between drought severity and protest. Specifically, we use digitalized data from the municipal elections of 1972 to control for previous ideological inclinations. We also control for voter turnout in 1982, the percentage of votes for the regime's candidate for mayor in 1982, and socioeconomic variables from 1970 and 1980. The inclusion of these variables does not significantly change our estimates, suggesting that our identification assumptions hold. Our findings are also robust to alternative measures of protest and samples. Additionally, as previously mentioned, we have also demonstrated that drought severity is not correlated with changes in local

political variables such as the percentage of votes for the military candidate at the municipality level and voter turnout, further reinforcing that our estimates are driven by voter behavior in the gubernatorial elections specifically.

We propose a probabilistic model to organize our empirical strategy and investigate the mechanisms linking natural disasters and support for authoritarianism. The model assumes that individuals vote to maximize their expected utility. They earn a certain labor income and expect losses due to adverse weather conditions based on their degree of vulnerability, which is independent of the party in power. The model also suggests that voters expect to receive disaster relief from the ruling party, which is proportional to the severity of the disaster. Additionally, voters have idiosyncratic utility from having a particular party hold office. The model suggests that the marginal effect of natural disasters on the percentage of voters for party A depends on the expected amount of transfers promoted by this party relative to the opposition. Specifically, if voters expect party A to provide more disaster relief than party B, the natural disaster will likely lead more voters to support party A. Under authoritarianism, voters have little reason to expect more transfers from the opposition, therefore the natural disaster will likely swing voters towards the authoritarian ruling party.

The conceptual framework suggests four factors that can intensify the marginal effect of natural disasters on voters' behavior. These factors are: the magnitude of expected transfers, the degree of vulnerability, the swing propensity, and the weight given to recent weather events when predicting future weather conditions. By implementing an interaction model with mean-centered variables of municipality characteristics, we find no statistically distinguishable effect among several proxies for each hypothetical mechanism listed above, except for municipalities with a higher economic dependence on crops that are resistant to drought shocks. These findings provide evidence that the degree of vulnerability of the electorate plays a significant role in connecting natural disasters and voter behavior.

When investigating mechanisms, we must consider the possibility that voters base their decisions on a regime's past actions rather than future promises. This theory could explain why municipalities with high levels of natural disaster damage may support an authoritarian government due to aid received during a crisis. However, our findings did not show any variation in disaster relief received by municipalities. Moreover, we have documented evidence of the mili-

tary regime exerting pressure on municipalities where the opposition vote was widely promoted. Therefore, we interpret our findings as natural disasters making the population more vulnerable and dependent on government support in the future.

Our paper contributes to various strands of economic literature, particularly in the area of political outcomes from natural disasters. Several works find that incumbent politicians are likely to be punished for adverse shocks they cannot control in democratic contexts (Achen and Bartels, 2017; Gasper and Reeves, 2011; Cole et al., 2012; Bodet et al., 2016; Smirnov et al., 2018). However, in non-democratic contexts, the results are ambiguous. For instance, Bruckner and Ciccone (2011) argue that economic adversity caused by natural disasters can be an opportunity for democratic transition, whereas Lazarev et al. (2014) show that wildfires in Russia raised support for the incumbent government at all levels. The provision of aid relief does not fully explain this support. Our results add further evidence indicating that natural disasters can be advantageous for despotic leaders.

Our paper also engages with the literature on participation in protests, since our response variable refers to a political demonstration against the incumbent government (Edmond, 2013; Enikolopov et al., 2020). Much of the literature in this area focuses on the role of information channels, such as social media, in facilitating political demonstrations. Our study extends this literature by showing that drought severity can act as a channel that precludes citizens from engaging in collective actions such as protests. Additionally, our study is closely connected to research on the rise of authoritarian leaders and the deterioration of democracy. For example, several studies have shown that the spread of social media has led to political polarization among voters and paved the way for populist leaders to win elections (Zhuravskaya et al., 2020; Levy, 2021).

Our work also aligns with a broader series of studies that connect climate change and economic development through institutional quality (Nordhaus, 2007; Dell et al., 2014; Burke et al., 2015, 2016; Auffhammer, 2018). We contribute to this literature by demonstrating that droughts can weaken people's motivation to participate in the defense of democracy. Additionally, similar to the findings of Bobonis et al. (2022), we identify voters' vulnerability as a crucial link between political support and natural disasters.

In the following section of the paper, we present a conceptual framework for our case study. In Section 2, we provide background information on the institutional context. In Section 4, we describe the data used in our analysis. Our results and potential mechanisms are presented in Section 5. Finally, in Section 7, we conclude the research paper.

2 Institutional Background

The Shrimp Vote Since the first direct election in 1884, Brazil has gone through cycles of political constraints and free elections. One notable period of authoritarianism was the military dictatorship that began with a *coup d'état* in 1964 and lasted until 1985. At the onset, military leaders abolished all political parties and established a two-party system, consisting of the pro-military regime party ARENA (National Renovating Alliance) and the opposition party MDB (Brazilian Democratic Movement). Despite allowing the population to elect mayors (with exceptions in state capitals and other significant cities) and legislative positions at all levels of government, military commanders alone held the power to appoint members of the executive branch, including the president, governors, and mayors of major cities. The dictatorship was characterized by the severe persecution of opponents, including torture, executions, and exile.

The military authorities pledged to reintroduce democracy through direct elections, but only under strict and orderly conditions. The tightly controlled elections of the time served as a means of measuring the speed at which this transition could take place without destabilizing the country. Protests and demonstrations against the military regime would delay the return to free elections. For example, in 1974, the contentious senate elections at the state level resulted in the postponement of the first scheduled gubernatorial elections in 1978, following the military's defeat at the polls.

In 1982, Brazilian voters were given the opportunity to vote for state governors for the first time since the military coup of 1964.[2] The election was supervised by the Brazilian electoral court (TSE) and held simultaneously across the country. Voters were required to write down either the name or number of each candidate for the six political positions in dispute, including both local and central government, as well as executive and legislative roles, such as governor,

[2]On February 5th, 1966, the military government created the Institutional Act 3, which established indirect elections for governors.

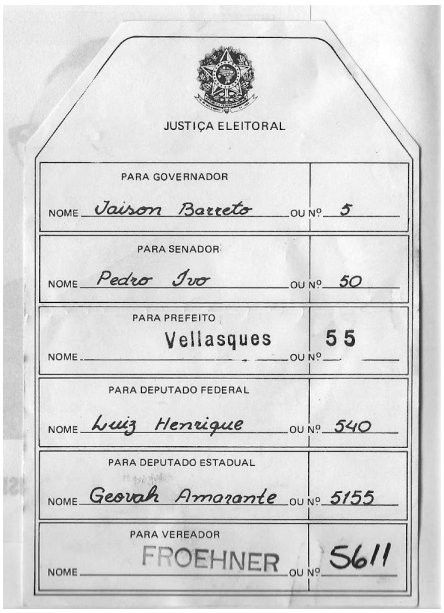
senator, mayor, and federal, state, and municipal deputy. The single paper ballot used to cast votes is shown in Figure 1.

In 1982, more than just two political parties were permitted to participate in the elections. Five parties disputed the elections: the ruling party PDS, which was the successor of the military party ARENA, and four opposition parties: PMDB, a successor of the MDB; PT, a leftist party; and two parties influenced by the ideology of former President Getúlio Vargas, the PDT and the PTB. However, as the ARENA and the MDB were the only two parties allowed to exist for nearly two decades, it was difficult for the newly-formed parties to field competitive candidates across the entire country. As a result, in practice, the 1982 elections were mainly disputed between the military party (PDS) and the opposition party (PMDB).

A unique feature of the 1982 elections, which is important for our study, was the implementation of the "voto vinculado" (linked vote). This new electoral rule prevented voters from choosing candidates from multiple political parties. If a voting ballot had numbers or names for candidates from different parties in any position, the electoral justice would cancel the vote and it would not be counted. According to Andrade (1985), the linked vote was designed to benefit PDS candidates in federal and state contests. The rule imposed additional challenges on the newly-formed parties. Furthermore, it increased the chances that local support for PDS candidates would translate into support at the federal and state levels. As noted in Ferraz et al. (2020), the military government was able to accommodate rival local political oligarchies within the same party through electoral legislation mechanisms (such as the *sublegenda* voting system). As a result, the linked voting rule would be particularly significant in the Northeast region, where the PDS had more control over municipalities. [3]

The military regime did not anticipate that the linked vote regulation would lead to a political movement against the central government. The regulation allowed voters to leave blank spaces for certain positions while filling in others with the number or name of candidates from the same party. In this way, voters could show their support for local positions without supporting the candidates for governor by casting a blank vote. This behavior became known as the shrimp vote

[3] As explained in Mainwaring et al. (1999), the military party dominated rural and small towns in Brazil, particularly in the Northeast, due to the combination of low levels of information and high dependence on government resources in these areas, which foster patronage politics. This is why the press labeled the PDS as "the party of the Northeast". We provide more details on this topic in the next subsection.



Notes: Figure illustrates an example of a 1982 ballot, arranged in the order of governor, senator, mayor, federal deputy, state deputy, and councilor.

Figure 1: 1982 election ballot

or *voto camarão*, where voters who had local political ties to the PDS but no political ties to the central government would vote for the mayor from the military party and leave the head of the ballot, the choice for governor, blank.

On May 22nd, 1982, the TSE officially allowed voters to leave blank spaces on their voting ballots while still casting a vote for other political positions, after being consulted by a federal representative from the PDS (Democratic Social Party).[4] This decision enabled democratic parties to campaign in favor of the shrimp vote in municipalities controlled by PDS politicians, and it also allowed PDS local authorities to express their dissatisfaction with the central command of the military party. For example, an article in the *Jornal do Brasil* reported that PDS politicians in the states of Rio Grande do Norte, São Paulo, Minas Gerais, Maranhão, and Pernambuco planned to use the shrimp vote as a form of protest against the gubernatorial candidates appointed by the military regime.[5]

The local candidates campaigned in favor of the shrimp vote by using various means such as playing jingles on the radio and distributing free t-shirts to encourage it. However, the central

[4]Jornal do Brasil, "TSE decide que é válida a cédula com voto em branco", May 22nd, 1982.
[5]Jornal do Brasil, "Decisão consagra 'voto camarão'.", May 22nd, 1982.

government, led by politicians tied to the military regime, responded by threatening voters who planned to cast the shrimp vote.[6] They stressed that the shrimp vote could be easily tracked and that they would punish municipalities with a high percentage of protest votes. An example of this is when, almost a month before the election, the military president João Figueiredo traveled to the municipality of Mossoró in the state of Rio Grande do Norte, to deliver a speech against the shrimp vote.[7]

The threats were not empty. Local authorities who encouraged the shrimp vote were penalized afterward. For instance, in the state of Ceará, where the PDS won the gubernatorial race, the governor fired public employees in places where the shrimp vote occurred more intensively[8]. Additionally, several mayors affiliated with the PDS in municipalities with higher shares of shrimp vote, noticed an unjustifiable drop in tax revenues from the central government[9]. Despite the penalties and threats, democratic politicians were still able to secure victories in several states, such as Minas Gerais and Mato Grosso do Sul, largely due to the support of the shrimp vote. This was evident in the defeat of the incumbent candidate in Minas Gerais, who lost to the democratic candidate supported by the shrimp vote.[10]

The narrative above suggests that many voters were unable to openly express their dissatisfaction with the authoritarian military party due to their local alliances. The shrimp vote provided a way for them to protest the regime without openly supporting it. This protest was driven by local politicians affiliated with the PDS who wanted to distance themselves from the authoritarian regime.[11] According to an official statement by the MDB, the shrimp vote was used as a last resort strategy by local PDS candidates to secure votes from their electorate.[12]

This paper utilizes the shrimp vote as a means of measuring the level of protest against the military regime. This measure is considered to be conservative, as it does not take into account voters who actively support the opposition across all levels of government. As a result, our findings may underestimate the impact of natural disasters on protesting against the military party. It is important to note that the shrimp vote is closely linked to the expectation of future

[6] Jornal do Brasil, "PMDB-AL investe no 'camarão"', October 24th, 1982.
[7] Jornal do Brasil, "Figueiredo repúdia 'voto camarão' em Mossoró", October 8th, 1982.
[8] Jornal do Brasil, "Ceará demite para punir o voto camarão", December 7th, 1982
[9] Jornal do Brasil, "Prefeito estranha queda no ICM", August 22nd, 1982
[10] Jornal do Brasil, "'Camarão' ajudou a derrotar Eliseu", November 18th, 1982.
[11] A Tribuna, "Candidatos do PDS estão omitindo a sigla partidária", September 1st, 1982.
[12] A Tribuna, "Origem do 'voto camarão"' November 3rd, 1982.

losses, which is a necessary requirement for hypothesis 1 to be valid. Due to the threats made by the central government, voters were likely to anticipate punishment if they chose to cast a shrimp vote.

Drought in the Brazilian Semi-arid Region The impact of droughts, a common natural disaster in Brazil, can be particularly severe in the semi-arid region of the country. This region is known to be impacted by droughts in cultural, social, and political ways, as reported by previous research (Campos, 2015).[13] The region is also the poorest in Brazil, with a predominantly rural population, small cities, and social indicators, such as infant mortality rates and education, being significantly worse than the rest of the country. Agricultural workers and their families in this region live permanently on the brink of survival.

During the 1979-1983 drought, the central government of Brazil implemented a plan to alleviate the negative effects of water scarcity in the semi-arid region. The plan had three main components: (1) providing jobs to individuals who lost their crops, (2) offering subsidized credit, and (3) providing water through means such as tank trucks. According to Pessoa (1987), the first pillar was the most crucial. The author also explains the nature of the jobs provided by the government, which were temporary positions within properties, mostly large farms in the region. These work fronts represented the only source of income for many impoverished households. The central government provided extensive support to the affected population, and according to Pessoa (1987), the population assisted by the emergency program represented half of the total labor force in the region in 1983.

This dependence on government resources in the Brazilian semi-arid region has led to a clientelistic relationship between voters and local landowners, who often hold political positions or have strong connections to politicians. These landowners employ many agricultural workers, exerting economic control over them and influencing their electoral decisions. As a result, landlords act as local vote brokers, securing thousands of votes for politicians without the need for direct contact with the electorate, as noted by Vilaça and de Albuquerque (1988).

[13] Droughts have been a persistent problem in the Brazilian semi-arid region for centuries, with reports dating back to the late 16th century when Brazil was a colony of Portugal. However, it was not until the late 19th century, when Brazil became an independent empire, that droughts in the semi-arid region became a national concern. It wasn't until the early 20th century, when Brazil became a republic, that the government took steps to address the issue by creating a department dedicated to improving infrastructure through the construction of dams and irrigation areas.

The existence of local brokers in the hinterland of the Northeast region of Brazil is a result of historical land inequality and oligarchical politics. Conservative parties have used this political system since Brazil's independence in 1822 (Ames, 2002; Mainwaring et al., 2000; Gans-Morse et al., 2014). Though these parties were weakened after the 1930s, the military coup renewed the clientelistic ties between landowners and local politicians, particularly in underdeveloped regions (Ferraz et al., 2020). The military party aimed to build political networks and clienteles within the underdeveloped interior of the country, as highlighted by Mainwaring et al. (2000, p. 173).

The patronage politics in the Northeast region of Brazil, as discussed previously, explains the strong control of the conservative party in local elections, as shown in the Figure 3 in the following section. This dominance is particularly notable in mayoral elections, highlighting the rigid political control at the local level. It seems unlikely that adverse weather conditions would have a significant impact on local elections. This hypothesis is supported by the empirical findings that the share of votes in mayoral elections was not affected by the drought. However, the support for governors could be affected by weather events. Adverse weather shocks could make voters more vulnerable and, as a result, more hesitant to protest against the dictatorship by casting a shrimp vote and potentially hurting governors belonging to the PDS party. Retaliation for shrimp votes, as promised during the electoral campaigns by the military government, could come in the form of decreased aid to alleviate the negative effects of droughts. Therefore, voters who are more negatively affected by the weather would be more vulnerable to retaliation and less likely to cast a shrimp vote.

3 Conceptual Framework

In this section, we present the theoretical foundation for our empirical analysis. The model we use is from the class of probabilistic voting models introduced by Lindbeck and Weibull (1987). This model highlights the conditions under which natural disasters may act in favor of autocratic regimes. Essentially, natural disasters result in economic losses for voters that the government can mitigate. Voters will support the political party they believe will provide more relief. If voters expect fewer benefits from protesting against the autocrat, more severe natural disasters will

decrease the incentive to support democracy. We discuss below why this assumption is plausible, especially in our study. One fundamental assumption is that individuals form expectations about future weather based on past observations, giving significant weight to recent experiences.

The Economic Model Individuals derive utility from their income $y(P, w)$ and idiosyncratic political preferences $d(p, P)$, both contingent on the political party in power $P \in \mathcal{P}$, with income dependent on the unknown weather shock w and d contingent on the voter type p. We adopt a linear additive utility function $u(p, P, w) = y(P, w) + d(p, P)$.[14] Voting takes place subsequent to the observation of the weather shock $\bar{w} \in \mathbb{R}$, yielding the formation of expectations regarding future weather shocks $w \in \mathbb{R}$, in accordance with the following assumption.

Assumption 1. *Voters' expectations about weather shocks w are given by*

$$w_{t|t} = w_{t-1|t-1} + \lambda(w_{t-1|t} - w_{t-1|t-1}), \tag{1}$$

where the subscript $t|t$ indicates that the expectation is formed at time t with information from time t.

In words, Assumption 1 means that the expected value of w at time t, based on information available at the beginning of t, is determined by the expected value of w at time $t-1$ given the information available at $t-1$, updated by the error correction term in parentheses. The weight assigned to the error correction term is denoted by λ. Proposition 1 follows from this assumption.

Proposition 1. *The expected weather shock is a combination of more recent information $\bar{w}$ and the history of shocks $\bar{h}$. Specifically,*

$$w = \lambda\bar{w} + (1-\lambda)\bar{h}, \tag{2}$$

where we simplify the notation by defining $w \equiv w_{t|t}$, $\bar{w} \equiv w_{t-1|t}$, and $\bar{h} = \sum_{i=1}^{t-1} \lambda(1-\lambda)^{t-1-i} w_{i-1|i}$.

Proof. This follows directly from the recursive solution of Equation (1). □

Individuals' income depends on their labor income ($c \in \mathbb{R}_+$), weather shocks ($w \in \mathbb{R}$), and the relief measures ($m(P, w) : \mathcal{P} \times \mathbb{R} \to \mathbb{R}$) promoted by the party P given the weather shock w. The income is then represented as $y(P, w) = c - \gamma[w - m(P, w)]$, where the parameter $\gamma \in [0, 1]$

[14] The choice of a linear utility function is made to simplify the exposition. Similar qualitative outcomes are attained with a quasi-linear utility function $u(p, P, w) = v(y(P, w)) + d(p, P)$, given that v is strictly increasing and concave.

measures the vulnerability of individuals to weather conditions. In the following, we assume that the disaster relief promoted by party P is a linear function of expected weather shocks, given by $m(P, w) = \tau(P)w$. We can interpret $\tau(P) \in [0, 1]$ as the share of the expected income loss that individuals expect the government to mitigate. Therefore, the expected net income promoted by party A is

$$y(A, w) - y(D, w) = \gamma(\tau(A) - \tau(D))(\lambda\bar{w} + (1 - \lambda)\bar{h}). \tag{3}$$

The Political Model The following setup is assumed to hold for both local and state elections independently. Although the interplay between local and state choices is crucial, the exposition is largely simplified by this assumption. Moreover, this assumption is not entirely unrealistic given the strong inclination towards the PDS party in our case study, enabling plausible conclusions from the model. We discuss this matter further below.

There are two parties denoted by $P \in \mathcal{P} = \{A, D\}$ and three types of voters denoted by $p \in \mathcal{P} \cup \{N\}$, where A stands for authoritarian (or PDS supporter), D stands for democratic (or MDB supporters), and N stands for neutral. When $p \in \mathcal{P}$, we say that the voter is a partisan, and her political benefit from having party P in power is one if $p = P$ and zero otherwise. Moreover, we assume that partisan voters consider only their political benefit when voting. In contrast, neutral voters consider the economic outcomes promoted by the party in power, although they also have political preferences. We normalize $d(N, D) = 0$ and assume that $d(N, A) \sim \mathcal{U}(-0.5/\sigma, 0.5/\sigma)$, where $\sigma \in \mathbb{R}_+$ is the swing propensity, and $\mathcal{U}$ represents a uniform distribution.

Let s be the share of neutral voters, and $0.5(1 + \delta)$ be the share of partisan voters supporting the PDS. The share of votes for the PDS in the electoral dispute $i \in \{m, g\}$ is given by

$$v_i^A = 0.5 + 0.5(1 - s_i)\delta_i + s_i\sigma(y(A_i, w) - y(D_i, w)), \tag{4}$$

where m denotes local elections and g denotes gubernatorial elections. Given the discussion in Section 2 where local politics were highly dominated by the PDS while there was no such domination at the state level, we assume that $s_m \to 0$ and define the shrimp vote as

$$\text{shrimp} \equiv v_m^A - v_g^A = 0.5[\delta_m - (1 - s_g)\delta_g] - s_g\sigma(y(A_g, w) - y(D_g, w)), \tag{5}$$

from which Proposition 2 follows.

Proposition 2. *The marginal effect of current weather shocks on the share of shrimp votes is given by*

$$\frac{\partial shrimp}{\partial \bar{w}} = (\tau(D) - \tau(A))s_g \sigma\gamma\lambda. \tag{6}$$

Proof. Follows directly from Equations (3) and (5). □

This implies that the marginal impact on protest votes depends on the disparity in expected weather mitigation promoted by the parties. Furthermore, the effect is more pronounced when there are more neutral voters, voters are more vulnerable to weather shocks, assign greater weight to recent information in forming their beliefs about future weather shocks, and when the swing propensity of neutral voters is higher.

Proposition 2 provides a rationale for different findings in empirical studies. It demonstrates that natural disasters can either benefit or harm incumbents, depending on what voters expect from them relative to the opposition. Equation (4) also reconciles the findings that disaster relief reduces political damage toward the incumbent. Although our model assumes that voters act prospectively, past disaster relief promoted by the incumbent may create positive expectations about future transfers. However, if voters anticipate the opposition performing better than the incumbent, the benefits from current relief may not be sufficient for reelection.

The model also suggests three magnifying effects. First, individuals more vulnerable to weather shocks will react more strongly, aligning with studies connecting politics and natural disasters through voter vulnerability (Bobonis et al., 2022). Second, the marginal effect of weather shocks is more robust when individuals assign greater weight to recent information when forming expectations about the weather. Empirical research indicates that more recent fluctuations in the climate are more influential in shaping individuals' beliefs about future weather conditions (Deryugina, 2013; Gichangi et al., 2015; Kala, 2017). Finally, the effect is stronger in areas with a higher swing propensity measured by the combination of s_g and σ. This effect is straightforward as it reflects how strongly a group reacts to policy relative to ideology. A higher σ implies smaller diversity in idiosyncratic preferences of neutral voters, reducing the share of voters changing their votes in response to policy.

In general, we need to model how voters form expectations about τ to predict the direction of the effect. We argue that we should expect weather shocks to favor the incumbent autocratic party. The first reason is pork barrel politics. It is evident from the historical accounts presented in Section 2 that voters should anticipate retaliation from the central government if they protest. Therefore, transfers were expected to be smaller should voters choose the MDB. The second reason is alignment effects. Selecting politicians from the same party in both local and state elections increases the probability of receiving future transfers. Since local politics are dominated by the PDS, the probability of future transfers increases when a governor from PDS is also selected.[15] These reasons suggest a negative relationship between natural disasters and protests against the autocratic party, a relationship that we empirically test next.

4 Data

Drought Index Droughts in the Brazilian semi-arid region are often attributed to low soil moisture retention rather than just low rainfall levels. Therefore, recent studies in climatology advocate for employing a combination of soil composition, temperature, and precipitation to measure soil moisture. This approach aims to enhance our understanding of the impacts of droughts, especially in the context of global warming (Dai, 2011, 2013; Trenberth et al., 2014; Martins et al., 2018; Short Gianotti et al., 2020; Pascolini-Campbell et al., 2021).[16]

We adopt a dryness measure inspired by the inverse Standardized Precipitation Evapotranspiration Index used in previous studies, such as Vicente-Serrano et al. (2010) and Albert et al. (2021). Specifically, we define dryness in location i during period t as

$$\text{Dryness}_{it} = \frac{(E_{it} - R_{it}) - (\bar{E}_i - \bar{R}_i)}{\xi_i},$$

[15] This argument can be made in a more complete version of the model where $p \in \mathcal{P} \times \mathcal{P}$. For example, when $p = (A, N)$, it means that the voter is partisan in local elections and neutral in state elections. In this case, we have nine types of voters. We can also assume that weather mitigation is a function of the party in each office, allowing for explicit alignment effects. We don't pursue this model since the assumption that most voters in local elections are partisans implies three types $p \in \{A\} \times \mathcal{P}$, which is similar to the analysis we performed.

[16] This methodology has also been adopted in prior economic studies, where researchers use metrics such as the aridity index (calculating the ratio of evaporation to rainfall) or measurements based on the difference between evapotranspiration and precipitation. Examples include studies by Cavalcanti (2018), Olivieri (2020), Smirnov et al. (2018), Albert et al. (2021), and Boffa et al. (2022).

where E_{it} represents the cumulative observed evaporation over 12 months in municipality i in month t, and $R_{i,t}$ represents the same for precipitation. Horizontal lines over the variables represent historical averages, and ξ_i is the standard deviation of $(E_{i,t} - R_{i,t})$ in municipality i. This index calculates the deviation of annual cumulative dryness from its historical mean, normalized by the standard deviation, and considers the difference between evapotranspiration and precipitation. Positive values suggest that the soil is retaining less water than usual, indicating a period of severe drought.

While the commonly used Standardized Precipitation Evapotranspiration Index is calculated using precipitation and potential evapotranspiration, in our study, we use an estimated index that incorporates observed evaporation. Observed weather data is considered more accurate than data gathered from satellites, as satellite measurements infer rather than directly measure rainfall and evaporation (Dell et al., 2014). We collect monthly weather data from 180 ground stations of the Brazilian Institute of Meteorology (INMET) from 1963 to 2018. The data includes objective measurements of precipitation and evaporation taken by pluviographs and Piche evaporimeters. We calculate a weighted average of each station's data for each municipality, using the square of the distance between the station and the municipality's centroid as the weight.

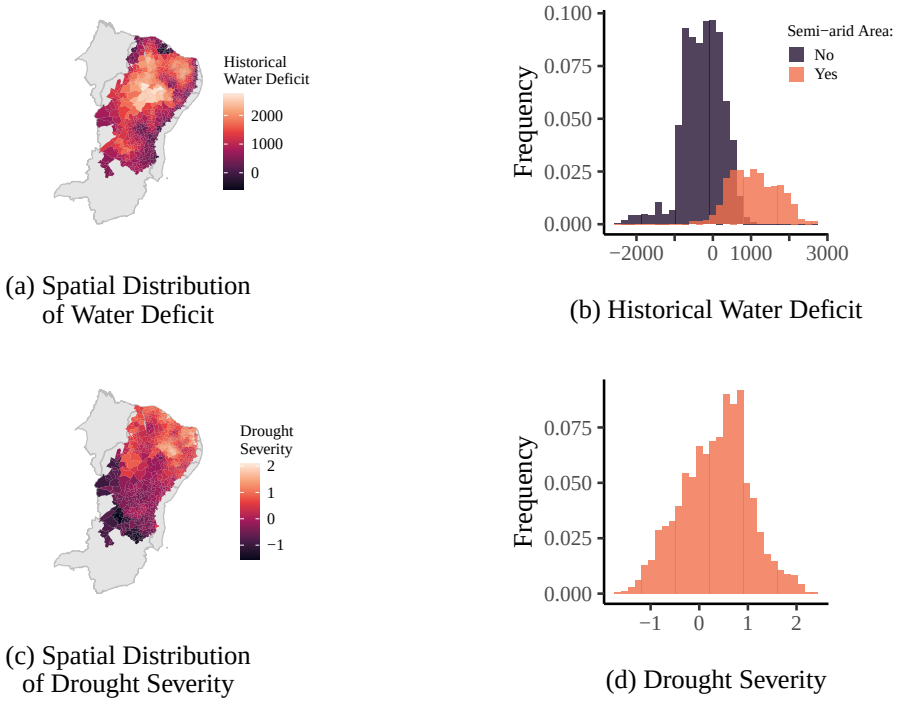
Finally, we adopt the definition of drought severity proposed by Brito et al. (2018) to quantify the intensity of dryness over an extended period, a crucial consideration for our focus on a prolonged hydrological drought (Dai, 2011). To assess drought severity in each municipality, we calculate the average dryness from 1979 to 1982 using the formula:

$$\text{Drought Severity}_{i,t} = \sum_{t=1979}^{1982} \frac{1}{4} \text{Dryness}_{it}. \tag{7}$$

We define each year t as starting in November of the previous year $(t-1)$ and ending in October of year t. In other words, the year 1979 runs from November 1978 to October 1979. This choice of time window aligns with the commonly reported onset of the natural disaster in 1979, with elections taking place in 1982 (Pessoa, 1987). We also conduct a robustness check using alternative measures of drought severity, detailed in Table 4.

The water scarcity data is visualized in Figure 2. Panels (a) and (b) depict the spatial distribution of the data in the semi-arid area, with the ten Brazilian states containing municipalities in the

semi-arid region shown in gray. Panel (a) illustrates the historical water scarcity in the semi-arid municipalities, while panel (b) highlights a higher degree of water deficiency compared to the rest of the country, emphasizing the severity of droughts in these areas. Panels (c) and (d) further demonstrate significant variability in the severity of the analyzed drought event, as calculated in Equation (7).



(a) Spatial Distribution of Water Deficit

(b) Historical Water Deficit

(c) Spatial Distribution of Drought Severity

(d) Drought Severity

Notes: a) spatial distribution of average water deficit between 1963 and 2018 in the semi-arid region. b) distribution among municipalities inside and outside the semi-arid region. c) spatial distribution of drought severity between 1979 and 1982. d) distribution of drought severity between 1979 and 1982.

Figure 2: Descriptive analysis of water deficit

Elections The data for the 1982 general elections is obtained electronically from the Superior Electoral Court of Brazil, retrieved from IPEADATA. It includes detailed information at the municipality level on voter turnout, the electorate, and votes received by each political party in each candidacy. Additionally, data from the 1972 municipal elections has been collected from the archive reports produced by the Superior Electoral Court in 1988.

Figure 3 illustrates the distribution of the vote share for PDS politicians in elections for governor, mayor, and legislative positions in municipalities inside and outside the semi-arid region.[17] The data reveals a significant influence of the military party in the semi-arid region. In the median municipality in the semi-arid region, the PDS receives at least 65% of the valid votes in all contested candidacies. In contrast, outside the semi-arid region, the median is at most 48%. This underscores the stylized fact discussed earlier about the capture of the semi-arid region by conservative parties, often represented by agrarian elites exerting substantial political influence over a large number of peasants. Notably, local elections are particularly skewed towards the military party, with the median share of votes for PDS candidates in mayoral elections reaching 81%. This is remarkable, mainly because the votes between candidacies were supposed to be aligned by construction.

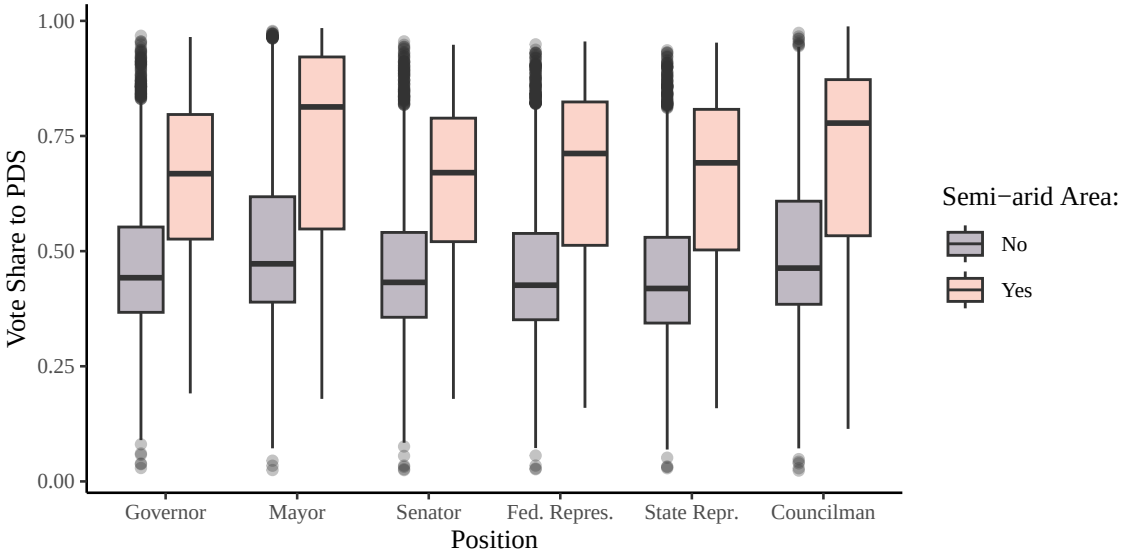


Figure 3: Vote share for PDS politicians in all positions disputed in 1982

Our metric for protest against the military dictatorship relies on the electoral phenomenon known as the shrimp vote. This behavior involves voting for a mayoral candidate, typically from PDS in the semi-arid region, and submitting a blank vote for governor, essentially tearing the ballot's "head". To construct our variable of interest, we compute the difference between the total number of valid votes for the PDS mayoral candidate and the PDS gubernatorial candidate,

[17] Boxes represent the interval between the first and third quartiles, while the horizontal line within them is the median. The upper and lower whiskers are $\min(x, 1.5 \times \text{IQR})$ and $\max(x, 1.5 \times \text{IQR})$, respectively, where IQR is the distance between the first and third quartiles. Observations beyond the whiskers are considered outliers.

divided by the total number of votes in each election. Mathematically, the shrimp vote is represented as $v_m - v_g$, where v_m and v_g denote the share of valid votes for PDS candidates in mayoral and gubernatorial elections, respectively.

This discrepancy in the number of votes for the PDS candidate in mayoral and gubernatorial elections reflects the electorate's choice to invalidate their ballot for the governor candidate while still voting for the PDS candidate in the mayoral election. This methodology offers a conservative measure of protest, as it does not account for individuals who opted to vote for the opposition in all electoral disputes. The distribution of shrimp votes both inside and outside the semi-arid region is depicted in the left panel of Figure 4. Notably, a substantial portion of the distribution is situated in the positive values for both areas, indicating more votes for the PDS locally than in state elections. The mass in the positive area is more pronounced in the semi-arid region, likely due to the significant share of votes for PDS candidates in mayoral elections. Given that election rules prohibited voting for politicians from different parties, this discrepancy is only possible if voters cast a blank vote for the governor. This strategy is illustrated in the second panel. Municipalities with a higher proportion of blank votes for governor exhibit a more substantial mismatch in the vote share for PDS candidates.

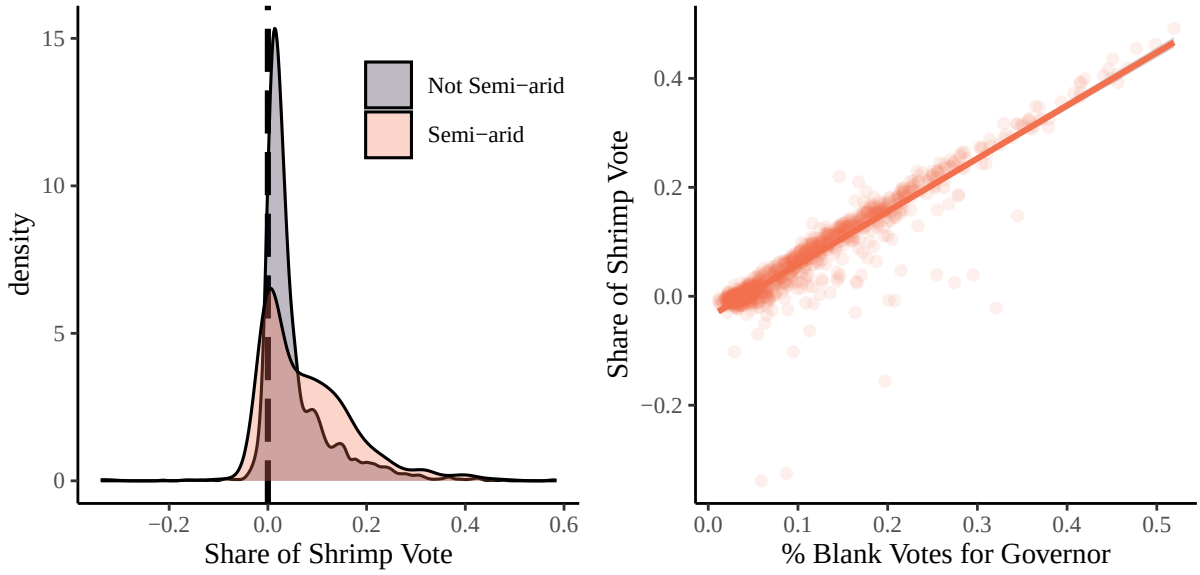


Figure 4: Shrimp vote distribution and its relationship with blank votes

5 Drought severity and protest against authoritarianism

Empirical strategy Motivated the combination of Equations (3) and (5), the following linear regression equation guides our empirical strategy:

$$Y_{m,s} = \alpha + \beta_0 D_{m,s} + \beta_1 H_{m,s} + \gamma X_{m,s} + \phi_s + \epsilon_{m,s}, \tag{8}$$

where $Y_{m,s}$ is the share of shrimp vote in municipality m in the state s. The variable $D_{m,s}$ is our measure of drought severity that represents the average deviation of the cumulative water deficit between November 1978 and October 1982, whereas $H_{m,s}$ represents the history of droughts measured by the averaged historical water deficit. The term $X_{m,s}$ is a set of municipalities characteristics, ϕ_s is a fixed effect of state, and $\epsilon_{m,s}$ is a random error term. We assume that the drought severity and the error term are uncorrelated, conditional on the observable geography, pre-condition variables, and unobservables characteristics common across municipalities within the same state. Under this assumption, which we discuss below, an OLS estimation will produce an unbiased estimate of β_0.

Our analysis is based on a sample of municipalities located in the semi-arid region, as currently defined. We exclude three states, Maranhão, Alagoas, and Sergipe, from our sample as they have very few municipalities in this region. However, it is worth noting that our results remain robust to alternative sample choices, as shown in Table 4. Our final sample includes 847 municipalities within seven states. Table 1 presents descriptive statistics of the variables used in our analysis for this primary sample. The statistics show that our sample includes municipalities with low levels of education, with an average of 38% of the population able to read and write. Additionally, the sample is primarily rural, with about 76% of households located in rural areas. Furthermore, the statistics show the high dominance of the authoritarian party, ARENA, where the average vote for them was an impressive 80% in 1972. The sample also contains municipalities with a large share of the area occupied by agricultural establishments. On average, the share of farmland is 76%.[18] It is also interesting to note that only a small share of farmland is irrigated. That is, most of the crops rely on rainfall to survive.

[18]The share of farmland computed as the area of agriculture establishments over the municipality's area. It is possible that establishments go beyond municipal boundaries, resulting in shares that go beyond one.

Table 1: Descriptive Statistics

Variables	Count	Mean	Std. Dev.	Min	Max
Shrimp Vote	847	0.08	0.09	-0.34	0.49
Drought Severity	847	0.45	0.67	-1.53	2.1
Geography:					
Historical Water Deficit	847	1108.16	615.28	-573.34	2743.12
Distance to River	847	103.25	71.23	0	403.58
Distance to Coast	847	221.13	151.15	4.08	735.56
Elevation	847	380.2	231.64	0	1268
Area	847	1164.73	1670.18	21.44	18437.4
Socio-economic:					
Share of Votes to ARENA (1972)	847	0.8	0.2	0.05	1
Share of Pop. in Rural Areas (1970)	847	0.76	0.15	0.07	0.98
Share of Literate (1970)	847	0.38	0.1	0.08	0.75
Population Density (1970)	847	30.76	35.26	1.2	414.27
GDP Per Capita (1975)	847	2025.75	1608.08	446.14	36862.9
Income Per Capita (1970)	847	35.31	14.6	12.18	194.81
Theil-T (1970)	847	0.32	0.11	0.12	0.87
Life Expectancy (1970)	847	48.27	4.02	38.4	58.24
Agriculture:					
Share of Farm Land (1975)	847	0.76	0.3	0.01	2.51
Share of Irrigated Land (1975)	847	0	0.01	0	0.14
Share of Pop. Working in Agr. (1975)	847	0.39	0.17	0.02	1.1
Share of Permanent Crops (1975)	847	0.28	0.26	0	0.98
Share of Corn Crops (1975)	847	0.22	0.13	0	0.71
Share of Cotton Crops (1975)	847	0.2	0.26	0	0.98
Share of Value of Perm. Crops (1975)	847	0.34	0.24	0	0.97
Share of Agric. Production (1975)	847	0.55	0.18	0.01	0.92
Share of Corn in Production (1975)	847	0.09	0.08	0	0.42
Share of Cotton in Production (1975)	847	0.15	0.22	0	0.97
Contemporary Electoral Variables:					
Share of Votes to PDS in City Council Elections	847	0.7	0.19	0.11	0.99

The sample encompasses municipalities in the Semiarid area with information about all variables used in the analysis. The shrimp vote is the difference between the share of votes for the PDS candidate in the mayoral and gubernatorial elections. Drought Severity is the average deviation from the historical water deficit between November 1978 and October 1982.

To further investigate the validity of the conditional independence assumption, we conduct an exercise to estimate the correlation between drought severity and the pre-determined characteristics of the municipalities. Specifically, we split our sample into municipalities below and above the median value of drought severity and then compared their characteristics. The results presented in Figure 5 show that drought severity is significantly associated with several municipality characteristics. For instance, the group with large drought severity had, on average, larger population density in 1970, lower income per capita in 1970, and less support for the military regime in the municipal elections of 1972. This discrepancy is somewhat expected since natural disasters are prone to high degrees of spatial correlation, evidenced in Figure 2. Therefore, when we condition the difference between the groups on state-fixed effects and geographical features, we cannot reject the null hypothesis that these two groups are similar, at a 95% confidence interval, for most of the variables. The exceptions are the share of agricultural production and the share of farmland, which are smaller among the municipalities with higher drought severity. This result suggests that we are dealing with a comparable set of municipalities after conditioning on geography and state fixed effects.[19]

We present our main results by controlling for state fixed effects and gradually introducing four sets of control variables: geography variables, socioeconomic pre-conditions, agriculture pre-conditions, and electoral variables. Geography variables refer to historical water deficit and the logarithm transformation of the distance to rivers, distance to the coast, elevation, and area. Socioeconomic pre-conditions are the share of population in rural areas in 1970, the share of literate in 1970, the logarithm of population density in 1970, the share of votes to ARENA (the military party) in the mayoral elections of 1972, the logarithm of GDP per capita in 1975, the logarithm of income per capita in 1970, the Theil-L index of income inequality in 1970, and the logarithm of life expectancy in 1970. Agriculture pre-conditions are measured in 1975 and include the share of farmland, the share of irrigated land, the share of population working agriculture, the share of permanent crops, the share of corn crops, the share of cotton crops, the share of agriculture value added on GDP, the share of the permanent crops in the agriculture value added,

[19] Although the fact that a few variables are still different among groups after controlling for fixed effects and geography is a point of concern, we show that our estimate is stable when we include socioeconomic and agricultural controls. It suggests that these variables are not driving our results. Moreover, we perform many alternative estimates to show that our results are robust.

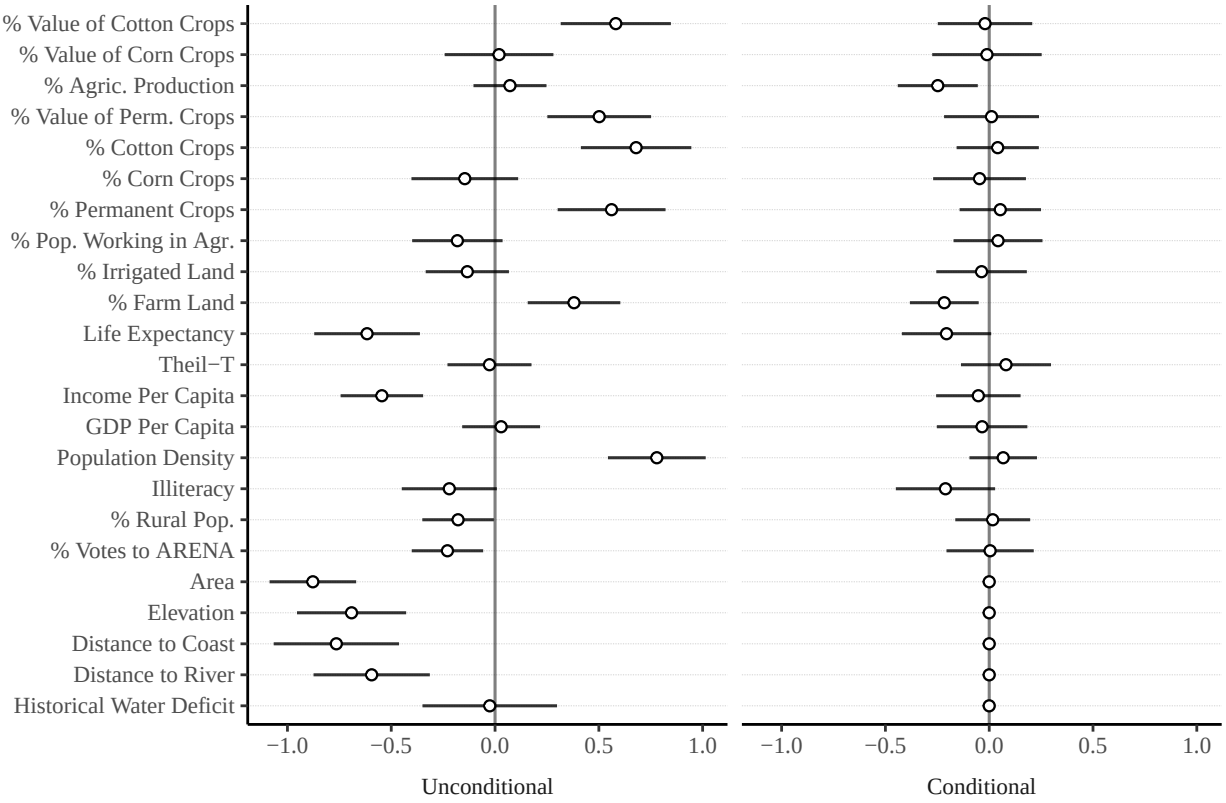


Figure 5: Correlation between Drought Severity and pre-existing conditions

the share of corn in the agriculture value-added, and the share of cotton in agriculture value added. Finally, electoral variables is the share of votes to the PDS in the city council elections in 1982.[20]

The introduction of the share of votes to the PDS in the city council election seeks to control for the most recent political inclination of a municipality. Nonetheless, the introduction of this variable raises concerns regarding the "bad control" bias.[21] Another source of concern stems from the fact that our response variable is composed of two electoral variables: share of votes to the PDS in mayoral and gubernatorial elections. This raises issues regarding the interpretation of the results as the effect may be prompted by either variables and our hypothesis suggests that it should be the outcome of changes in the share of votes in the gubernatorial elections.

To alleviate these concerns, we present in Table 2 a first set of results where the dependent variables are electoral variables in 1982. All columns controls for state fixed effects, geography, socioeconomic, and agriculture variables. Columns (2) and (4) also control for the electoral variables listed in Table 1. There are two important lessons from these results. First, the effects of drought severity on the share of PDS votes are much stronger in gubernatorial election than in mayoral elections, especially when we do not control for electoral variables. Therefore, the effects on shrimp vote are driven by changes in the share of votes in the governor dispute. Second, there is no statistically significant correlation between drought severity and the share of votes in the city council elections, which reduces concerns regarding the "bad control" bias. It also reassuring that our results do not depend on controlling for contemporary electoral variables, as we discuss next.

Main results The main results in Table 3 demonstrate the impact of drought severity on shrimp vote. As mentioned before, all columns control for state fixed effects. Columns (2) to (4) introduce controls to the control groups in Table 1 in a step-wise manner. All errors are clustered at the micro-region level, which allows for a certain degree of spatial correlation. The first column

[20] Historical water deficit is measured between 1960 and 2018, whereas distances are computed using shape-files from the National Institute for Space Research. They are the Euclidean distance from municipal seats to either rivers or the coast.

[21] For example, denote the share of votes to the PDS in the city council elections by Z and ignore the subscripts. We want to test the relationship between drought severity D and the shrimp vote Y: $D \to Y$. Now, suppose that D causes Z but does not causes Y and there is an unobserved variable U causing both Z and Y. In that case, the introduction of Z creates a "collider" path $X \to Z \leftarrow U \to Y$ implying correlation where there is no causation.

Table 2: The Effect of Drought Severity on Contemporaneous Electoral Variables

	Mayor		Governor		Council
	(1)	(2)	(3)	(4)	(5)
Drought Severity	0.007	-0.007*	0.037**	0.027***	0.014
	(0.017)	(0.004)	(0.015)	(0.009)	(0.016)
Observations	847	847	847	847	847
R^2	0.29	0.96	0.32	0.82	0.29
Cluster Groups	131	131	131	131	131
Controls:					
% PDS in Council		✓		✓	

Standard errors clustered at the micro-region level in parentheses. All columns include state fixed effects, geography, socioeconomic, and agriculture controls. % PDS in Council is the share of votes for PDS candidates in the city council dispute. $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$

shows that there is a negative relationship between drought severity and shrimp vote, with a coefficient of -0.019, although not statistically significant at 10%. Column (2) shows that when we control for geography variables, the coefficient becomes statistically significant and increases in absolute terms to -0.026. In Column (3), when socioeconomic variables are added as controls, the coefficient is -0.028. Adding agriculture controls changes it slightly to -0.029. Finally, when we control for the share of votes for PDS candidates in the city council dispute in Column (5), the coefficient remains statistically significant and equals -0.034. Overall, these results suggest that drought severity has a significant negative impact on shrimp vote and that this relationship remains robust even when controlling for various factors. It is also important to notice that the magnitude of the effect changes only slightly as we introduce control variables, suggesting a direct, robust effect of drought on the reduction of protest voting.

The impact of drought severity on protest votes against the military regime is significant. Let $\beta = -0.03$, then a median drought severity shock of 0.54 implies a reduction of 1.6 percentage points in the percentage of shrimp votes. Alternatively, a stronger shock of the size of the 90% percentile equal to 1.23 implies a reduction of shrimp votes by 3.7 percentage points. In practical terms, this means that a median semi-arid municipality with 6,000 voters that experiences a weather shock similar to the municipality in the 90^{th} percentile would see a decrease of 222

Table 3: The Effect of Drought Severity on Shrimp Vote

	(1)	(2)	(3)	(4)	(5)
Drought Severity	-0.019	-0.026**	-0.028**	-0.029***	-0.034***
	(0.011)	(0.012)	(0.011)	(0.011)	(0.010)
Observations	847	847	847	847	847
R^2	0.09	0.1	0.13	0.15	0.46
Cluster Groups	131	131	131	131	131
Controls:					
Geography		✓	✓	✓	✓
Socioeconomic			✓	✓	✓
Agriculture				✓	✓
% PDS in Council					✓

Standard errors clustered at the micro-region level in parentheses. All columns include state fixed effects. Geography, Socioeconomic, and Agriculture controls for the corresponding variables in Table 1. % PDS in Council is the share of votes for PDS candidates in the city council dispute. $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$

protest votes. However, while our data suggests that the military regimes benefited from instances of intense, long-lasting drought, it is clear that other factors also played a role in their electoral victories. In most northeastern states we studied, the pro-military party candidate won with more than 60% of the valid votes. However, in close elections, even a small shift in support can have a significant impact. For example, in the state of Pernambuco, the pro-military party candidate won with only 52.5% of valid votes, making it possible that severe droughts played a role in their election.

Table 4 presents the results from a series of different specifications and sample choices. All columns control for state fixed effects, geography, socioeconomic, and agriculture variables. Panel B adds the share of votes for PDS candidates in the city council dispute as a control variable. Column (1) shows that the results are robust to an alternative definition of shrimp vote, where instead of the share with respect total votes, we take the share with respect to local votes for the PDS. Effectively, the new measure of shrimp votes is $(1 - v_g/v_m)$, which we call shrimp ratio. Column (2) shows that the results are robust to truncating our dryness variable at zero. Specifically, we replace Dryness_{it} by $\max\{\text{Dryness}_{it}, 0\}$ in Equation (7). This transformation reduces concerns that our results may be driven by extreme events related to excessive

rainfall (Rocha and Soares, 2015). Columns (3) expands the sample to municipalities covered by the SUDENE, which was the government agency responsible by the economic development of the region. Column (4) excludes climate data prior to November 1979 from calculations. That is, it takes into account only the last three years before the elections. Column (5) uses a binary explanatory variable indicating if a municipality is above or below the median of the drought severity variable. Finally, Column (6) presents Conley (1999) standard errors with a 150km cutoff. It's important to note that the results not only remain consistent in their interpretation but also remain quantitatively robust to these alternative specifications.

Table 4: The Effect of Drought Severity on Shrimp Vote - Alternative Specifications

	Shrimp Ratio	Truncated	Sudene	No 1979	Dummy	Conley (150km)
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A - No % PDS in Council						
Drought Severity	-0.036***	-0.024**	-0.027**	-0.023**	-0.020**	-0.029**
	(0.012)	(0.011)	(0.011)	(0.010)	(0.009)	(0.012)
R^2	0.14	0.15	0.15	0.15	0.15	0.15
Panel B - % PDS in Council						
Drought Severity	-0.041***	-0.030***	-0.031***	-0.028***	-0.025***	-0.034***
	(0.012)	(0.011)	(0.010)	(0.010)	(0.008)	(0.012)
R^2	0.41	0.46	0.45	0.46	0.46	0.46
Observations	847	847	902	847	847	847

Standard errors clustered at the micro-region level in parentheses. All columns control for state fixed effects, geography, socioeconomic, and agriculture variables. Panel B adds the share of votes for PDS candidates in the city council dispute as a control variable. $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$

Is it protest? Figure 6 supports our conclusion that drought leads to a decrease in protests rather than other factors causing a decline in shrimp votes. It is possible that more severe droughts make it harder for voters to access information about candidates or increase voter apathy. The columns in Figure 6 show the results of our most comprehensive analysis, using the difference in vote shares for PDS candidates in mayoral and other positions in dispute, including the governor's office, senate, federal chamber, state chamber, and local councilor. The results are more robust for majoritarian positions, particularly for the governor's office, which was the main focus of protests against the military dictatorship in 1982. Additionally, in proportional legisla-

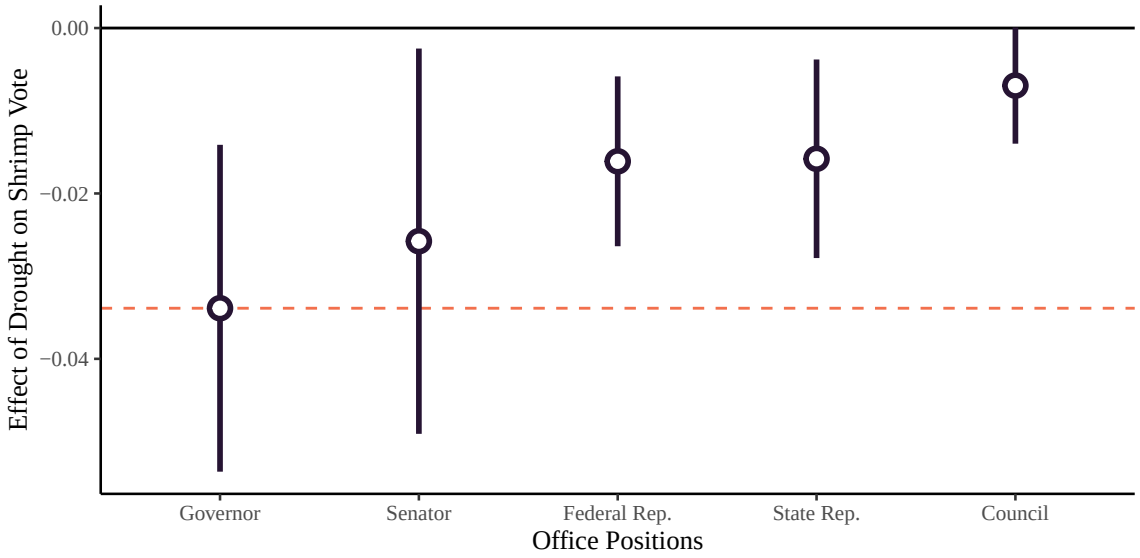


Figure 6: Marginal effect of Drought in the share of vote to PDS in other positions

tive positions, where there is a larger pool of candidates, inattention and lack of information are more likely to occur. Furthermore, for legislative positions, voters had to remember either a candidate's name or a four-digit number, compared to a one-digit number for a candidate running for the governor's office.[22] Finally, the governor's race appears first on the ballot, as shown in Figure 1. Research has demonstrated that races that appear earlier on the ballot tend to receive more votes (Miller and Krosnick, 1998; Blom-Hansen et al., 2016). Therefore, one would expect to see fewer blank votes in the governor's race; however, the opposite is observed.

6 The Connection Between Drought Severity and Protest

Next we investigate the connection between drought severity and the share of shrimp votes in a municipality. The goal is to understand the mechanism through which this relationship is build. Our theoretical model highlights several reasons why natural disasters can impact the share of votes. Namely, (1) expected transfers, (2) vulnerability degree, (3) swing propensity, and (4) how expectations are formed. To test these channels, we rely on two alternative approaches. First, we test if variables directly affected by the Drought are mediator variables along the lines of the

[22]See Schneider and Senters (2018) for a discussion on the importance of candidates' numbers for elections in Brazil. Fujiwara (2015) shows that Brazilian paper ballots were characterized by votes riddled with errors and that the introduction of electronic voting in 1998 promoted the enfranchisement of less educated voters.

classical work of Baron and Kenny (1986). Next, we test for heterogeneous effects along a large set of predetermined variables.

The main challenge in the first approach is to obtain relevant data for the studied period. We utilize data about relief transfers from digitalized archival sources at the SUDENE's library. Although we cannot find the exact amount transferred to each municipality, we use the date when the central government approved the petition declaring the municipality in emergency status. Then, we assume that the number of days between being assigned emergency status and the election is a good proxy for the amount of transfers received before the election. To measure vulnerability, we use data from the Municipal Agricultural Survey that provides annual information about agricultural production starting in 1974. Specifically, we utilize this data to build the growth of the value of total agricultural production, agricultural production of corn, and agricultural production between 1979 and 1982.[23] While agricultural production measures how a given municipality was economically affected by the Drought, we also test for a social dimension of vulnerability using information about child mortality between 1979 and 1982 from the Brazilian Unified Health System. Finally, we investigate whether the results are driven by a reduction in turnout due to the drought. The turnout rate also serves to address concerns related to migration, because, given the mandatory nature of voting in Brazil, low turnout implies that a significant portion of the electorate is absent from its electoral district. The underlying assumption is that drought refugees did not promptly update their electoral district upon arriving at their destinations.

The results are presented in the Table 5. Each column represents one possible mediation variable described above. All columns include state fixed effects and the same control variables as in Column (5) of Table 3. Observations vary due to data availability, except in Column (1), where we keep only municipalities that were considered to be in emergency status. Panel A shows that Drought Severity has a positive relationship with the number of days a municipality was assigned emergency status before the election. Moreover, more severe droughts are associated with the slower growth of agricultural production of corn. The effects on child mortality, turnout rates,

[23]The rationale for choosing corn and cotton as measures of economic vulnerability is explained by Pessoa (1987) on page 477. The author emphasizes that corn was mainly produced for subsistence consumption and its crops were vulnerable to dryness. On the other hand, cotton production was more resistant to droughts, and revenue would often be shared between workers and the landowner.

and total agricultural growth are negative but not statistically different from zero, while the effect on the growth of cotton production is positive but not statistically significant. Panel B repeats the estimation in Column (5) of Table 3 since we have different samples in Columns (1), (2), (5), and (6). Interestingly, the coefficients are very similar for these alternative samples, with the exception of Column (6), where the number of observations is significantly smaller. Panel C tests if each potential mediation variable is the mechanism through which Drought Severity affects the share of shrimp votes. If that is the case, we should observe different coefficients associated with Drought Severity in Panels B and C. However, that is not the case. All coefficients are virtually unchanged when we control for the variables studied.[24]

Table 5: Mediation Analysis

	Relief	Child		Agricultural Production Growth		
	Days	Mortality	Turnout	Total	Corn	Cotton
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A - Dependent Variable: Mediator						
Drought Severity	0.096***	-0.064	-0.004	-0.026	-0.125*	0.012
	(0.025)	(0.104)	(0.009)	(0.019)	(0.070)	(0.069)
R^2	0.45	0.26	0.23	0.37	0.26	0.33
Panel B - Dependent Variable: Shrimp Vote						
Drought Severity	-0.031***	-0.027***	-0.034***	-0.034***	-0.035***	-0.015
	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
R^2	0.45	0.46	0.46	0.46	0.46	0.47
Panel C - Dependent Variable: Shrimp Vote						
Drought Severity	-0.030***	-0.027***	-0.034***	-0.034***	-0.036***	-0.015
	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
Mediator	-0.008	-0.002	-0.004	-0.017	-0.006	0.004
	(0.017)	(0.005)	(0.035)	(0.020)	(0.007)	(0.009)
R^2	0.45	0.46	0.46	0.47	0.46	0.47
Observations	791	661	847	847	764	456
Cluster Groups	126	120	131	131	131	90

Standard errors clustered at the micro-region level in parentheses. All columns control for state fixed effects, geography, socioeconomic, and agriculture variables, and the share of votes for PDS candidates in the city council dispute as a control variable. $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$

[24]The results are qualitatively unchanged if we exclude electoral controls from the analysis. When we include municipalities that were never considered in emergency status in the estimation in Column (1), the qualitative results are also unchanged, but the the effect of the drought on the relief in Panel A is now negative and not statistically significant and the effect of relief on the shrimp vote in Panel C is still negative but now statistically significant.

Perhaps the more striking result from the previous analysis is the lack of effect of relief transfers on the share of shrimp vote. While a large strand of the literature makes the connection between natural disasters and electoral success through disaster relief transfer, we are unable to reach the same conclusion. As displayed in Panel C, more relief transfers reduce protest, but only slightly and the effect is not statistically significant. Moreover, the effect of Drought Severity is unchanged. We provide two possible explanations for this result. First, we recognize that our measure of natural disaster relief is not ideal and a more accurate measure could lead to different results. Nonetheless, we don't think such data is available in our case. Second, our results may be the outcome of the alternative institutional setting the relationship is tested on. Under democracies, relief transfers may represent a positive signal of competence or alignment of incumbents increasing their chances of reelection. In our setting, protest does not mean reelecting incumbents. It means demonstrating dissatisfaction assuming the risk of future punishment. The results above highlight that relief transfers did not change individuals willingness to take that risk.

Heterogeneity Since we failed to identify mechanisms using the set of variables available to us after the onset of the studied drought, we investigate heterogeneous effects among municipalities with different characteristics that could shed light on drivers of such a relationship. To do so, we will focus on predetermined variables that we can associate with the model parameters explaining the effects of natural disasters on support to politicians. We use four variables to test heterogeneous effects related to economic vulnerability (γ). Namely, the share of GDP from agricultural production, the share of corn and cotton in agricultural production, and the share of land irrigated in 1975. The second feature we consider is the relevance of policy to voting choices (s and σ). We posit that the level of control exerted by rural elites over peasants can influence the concentration of political preferences. In situations of widespread clientelism, landowners may exert a significant degree of control over the political choices of peasants, resulting in a narrower σ. To measure this control, we use metrics such as literacy rate and income inequality (Theil-L) in 1970.[25]

[25] Although our model also identifies the weight citizens assign to previous climate conditions in forming their prospective beliefs (λ) as a potential source of heterogeneity, we don't believe that any of our variable can capture such variation.

The strategy to test heterogeneity among the mentioned variable is to include the following interaction term in Equation (8): $\beta_3(D_{m,s} - \overline{D}) \times \widehat{M}_{m,s}$, where $\overline{D}$ is the average drought severity and $\widehat{M}_{m,s}$ is a standardized version of variable $M_{m,s}$ included in $X_{m,s}$. We use the standardized version of $M_{m,s}$ so that the estimated β_0 equals the estimated value in Table 3 when $M_{m,s}$ is measured at its average. We are therefore interested in the linear combination of coefficients β_0 and β_3, representing the heterogeneous effect of drought severity according to the characteristic $M_{m,s}$. The results are presented in Table 6.

The variable tested that presents a significant coefficient at the interaction term is the share of irrigated land. Area in which the share of irrigated land is one standard deviation above the mean observe effects from natural disasters that are half in magnitude compared to areas in the mean. The findings suggest that economic losses in populations highly vulnerable to climate shocks may decrease the likelihood of citizens engaging in collective action in favor of more democracy. The results align with previous studies linking voter behavior to the degree of vulnerability to natural disasters Bobonis et al. (2022).

Table 6: Dependent Variable: Shrimp Vote

	Literacy Rate	Theil - L	Irrigated Land	Agricul. Prod.	Corn Prod.	Cotton Prod.
	(1)	(2)	(3)	(4)	(5)	(6)
Drought Severity	-0.033***	-0.034***	-0.033***	-0.033***	-0.034***	-0.034***
	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Het. Variable	0.005	0.002	0.015***	-0.003	0.0010	0.009
	(0.005)	(0.003)	(0.004)	(0.004)	(0.005)	(0.007)
Observations	847	847	847	847	847	847
R^2	0.46	0.46	0.47	0.46	0.46	0.46
Cluster Groups	131	131	131	131	131	131

Standard errors clustered at the micro-region level in parentheses. All columns control for state fixed effects, geography, socioeconomic, and agriculture variables, and the share of votes for PDS candidates in the city council dispute as a control variable. $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$

7 Conclusion

In this research, we aimed to understand the relationship between natural disasters and protests against autocratic regimes using data from the 1979-1983 Drought in the Brazilian semi-arid region. We utilized meteorological data to measure the deviation from historical means of water deficit as the primary explanatory variable and considered geographical, developmental, and electoral variables in our analysis. Our findings suggest that adverse weather conditions have a negative effect on protests against the military regime. However, we did not find evidence that disaster relief provided by the government, income inequality, or social vulnerability measures drive this effect. Instead, the effect seems to be heterogeneous based on the degree of economic vulnerability, as measured by the importance of cotton for local production. This suggests that economic vulnerability may be a relevant mechanism at play.

Additionally, we proposed a probabilistic voting model that reconciles mixed findings in the literature and guided our empirical exercise. The model predicts that under authoritarian regimes, individuals have no incentive to protest or punish incumbent politicians due to adverse weather conditions, as it may result in punishment towards the voters. It is worth noting that this study focuses on a specific type of protest, in which individuals express their disapproval of the central government and does not rule out the possibility of protests increasing due to natural

disasters when individuals believe they are strong enough to overthrow the authoritarian regime, as found in previous studies (Bruckner and Ciccone, 2011).

A Tables

Table 1: The Effect of Drought Severity on Alternative Measures of Shrimp Vote

	Governor	Senator	Federal Rep.	State Rep.	Council
Drought Severity	-0.025	-0.017	-0.014	-0.012	-0.012
	(0.008)***	(0.009)*	(0.005)***	(0.005)**	(0.004)***
Observations	848	848	848	848	848
State FE	Yes	Yes	Yes	Yes	Yes
Geography	Yes	Yes	Yes	Yes	Yes
Electoral	Yes	Yes	Yes	Yes	Yes
Development	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses. Drought Severity (Nov 1978 - Oct 1982) is average SPEI between November of 1978 and October of 1982. Geography variables include historical averaged water deficit, distance to rivers, and distance to the coast. Electoral variables include turnout rate, vote share to ARENA (military party) in 1972 and vote share to the PDS candidate in the 1982 mayorial election. Development variables include the share of population living in rural areas in 1970 and 1980, population density in 1970 and 1980, and the share of literate adults in 1970 and 1980. $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$

B Data Description

Shrimp Vote: The difference between the share of votes for PDS candidates in municipal elections and the share of votes for PDS candidates in gubernatorial elections. **Source:** Constructed

Share of Votes to PDS Candidates in Any Election: Votes for PDS candidates in a given election over the total votes. **Source:** Constructed

Votes to PDS Candidates in Any Election: Number of votes for candidates affiliated with the PDS party in a given election. **Source:** Superior Electoral Court. Retrieved from IPEADATA

Total Votes: Number of votes for candidates affiliated with any party plus blank and null votes. **Source:** Superior Electoral Court. Retrieved from IPEADATA

Drought Severity: Average dryness between 1979 and 1982. **Source:** Constructed

Dryness: Standardized difference between evapotranspiration and precipitation. **Source:** Constructed

Evapotranspiration: Monthly weather data from 180 ground stations from 1963 to 2018. **Source:** Brazilian Institute of Meteorology (INMET)

Precipitation: Monthly weather data from 180 ground stations from 1963 to 2018. **Source:** Brazilian Institute of Meteorology (INMET)

Historical Water Deficit: Average difference between evapotranspiration and precipitation between 1963 and 2018. **Source:** Constructed

Distance to River: Shortest distance between municipal seats and rivers. **Source:** Constructed

Municipal Seat: Geographical location of municipal seats. **Source:** GeoBR

Rivers: Shapefiles containing the location of major rivers. **Source:** Brazilian Institute of Spatial Studies

Distance to Coast: Shortest distance between municipal seats and the coast. **Source:** Constructed

Coast: Shapefile containing the location of the coast. **Source:** Brazilian Institute of Spatial Studies

Elevation: Median elevation. **Source:** Brazilian Institute of Spatial Studies

Area: Municipal area. **Source:** GeoBR

Share of Votes to ARENA: Votes to ARENA candidates in municipal elections over the total votes. **Source:** Superior Electoral Court

Share of Population in Rural Areas (1970): Rural population over total population. **Source:** Constructed

Rural Population: Population residing in rural areas. **Source:** Census. Retrieved from IPEADATA

Total Population: Population residing in a given municipality. **Source:** Census. Retrieved from IPEADATA

Share of Literate: One minus the share of illiterates. **Source:** Constructed

Share of Illiterates: Share of the population over 15 years old that cannot either write or read a note. **Source:** Census. Retrieved from IPEADATA

Population Density: Total population over area. **Source:** Constructed

GDP per Capita in 1975: Total GDP in 1975 over the average total population in 1970 and 1980. **Source:** Constructed

Total GDP in 1975: Municipal Gross Domestic Product measured in 2010 BRL. **Source:** Brazilian Institute of Geography and Statistics

Income per Capita: Average per capita household income transformed from September 1991 minimum wages to 2010 BRL using a minimum wage equal to $42,000$, transforming in BRL by dividing by 5.5×10^6 and deflating using the consumer price index. **Source:** Census. Retrieved from IPEADATA

Theil-L: Theil-L index of inequality using household per capita income. **Source:** IPEA

Life Expectancy (1970): Life expectancy at birth. **Source:** IPEA

Share of Farmland: Farmland over municipal area. **Source:** Constructed

Farmland: Area of agricultural establishment. **Source:** Agriculture Census. Retrieved from IPEADATA

Share of Irrigated Land: Irrigated land over farmland. **Source:** Constructed

Irrigated Land: Irrigation is the practice of applying water, other than that from rain, directly to the surface of cultivated soil with pastures or crops, in specified quantities and intervals, with the purpose of providing water to plants under conditions suitable for their growth and production. **Source:** Brazilian Institute of Geography and Statistics

Share of Population Working in Agriculture (1975): Agriculture workers in 1975 over the average population between 1970 and 1980. **Source:** Constructed

Agriculture Workers: Workers whose occupation falls into the agriculture industry. **Source:** Brazilian Institute of Geography and Statistics

Share of Permanent Crops: Area of permanent crops harvested over the total harvested area. **Source:** Constructed

Total Harvested Area: Area of permanent and temporary crops harvested. **Source:** Constructed

Permanent Crops Harvested Area: Area in which permanent crops were harvested. **Source:** Municipal Agriculture Survey

Temporary Crops Harvested Area: Area in which temporary crops were harvested. **Source:** Municipal Agriculture Survey

Share of Corn Crops: Area of corn crops harvested over the total harvested area. **Source:** Constructed

Corn Crops Harvested Area: Area in which corn crops were harvested. **Source:** Municipal Agriculture Survey

Share of Cotton Crops: Area of cotton crops harvested over the total harvested area. **Source:** Constructed

Cotton Crops Harvested Area: Area in which cotton crops were harvested. **Source:** Municipal Agriculture Survey

Share of Value of Permanent Crops: Value of permanent crops harvested over the total value of crops. **Source:** Constructed

Total Value of Crops: Value of permanent and temporary crops harvested. **Source:** Constructed

Value of Permanent Crops: Sum of permanent crops individual commodities production times their national prices. **Source:** Constructed

Permanent Crops Production: Quantity produced of permanent crops. **Source:** Municipal Agriculture Survey

Value of Temporary Crops: Sum of temporary crops individual commodities production times their national prices. **Source:** Constructed

Temporary Crops Production: Quantity produced of temporary crops. **Source:** Municipal Agriculture Survey

Share of Value of Corn Crops: Value of corn crops harvested over the total value of crops. **Source:** Constructed

Value of Corn Crops: Corn crop production times their national prices. **Source:** Constructed

Corn Crop Production: Quantity produced of corn. **Source:** Municipal Agriculture Survey

Share of Value of Cotton Crops: Value of cotton crops harvested over the total value of crops. **Source:** Constructed

Value of Cotton Crops: Cotton crop production times their national prices. **Source:** Constructed

Cotton Crop Production: Quantity produced of cotton. **Source:** Municipal Agriculture Survey

Relief Days: Number of days between active emergency status and election day (Nov 15, 1982). **Source:** Constructed

Active Emergency Status: Date emergency status is recognized by the central government. **Source:** Archival documents produced by the Sudene in 1982

Child Mortality: Number of child deaths over the population below 5 years old in 1980. **Source:** Constructed

Child Deaths: Number of child and infant deaths (below 5 years old) between 1979 and 1982. **Source:** Datasus

Turnout Rate: Total votes over voters. **Source:** Constructed

Voters: Population eligible to vote. **Source:** Superior Electoral Court. Retrieved from IPEADATA

Total Agricultural Production Growth: Average growth of the value of total value of crops between 1979 and 1982. **Source:** Constructed

Corn Agricultural Production Growth: Average growth of the value of corn crops between 1979 and 1982. **Source:** Constructed

Cotton Agricultural Production Growth: Average growth of the value of cotton crops between 1979 and 1982. **Source:** Constructed

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