Chapter 1: Does Drought Cause Severe Famine?

Geography and Mortality of the 1877-1879 Drought in Northeast Brazil

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Introduction

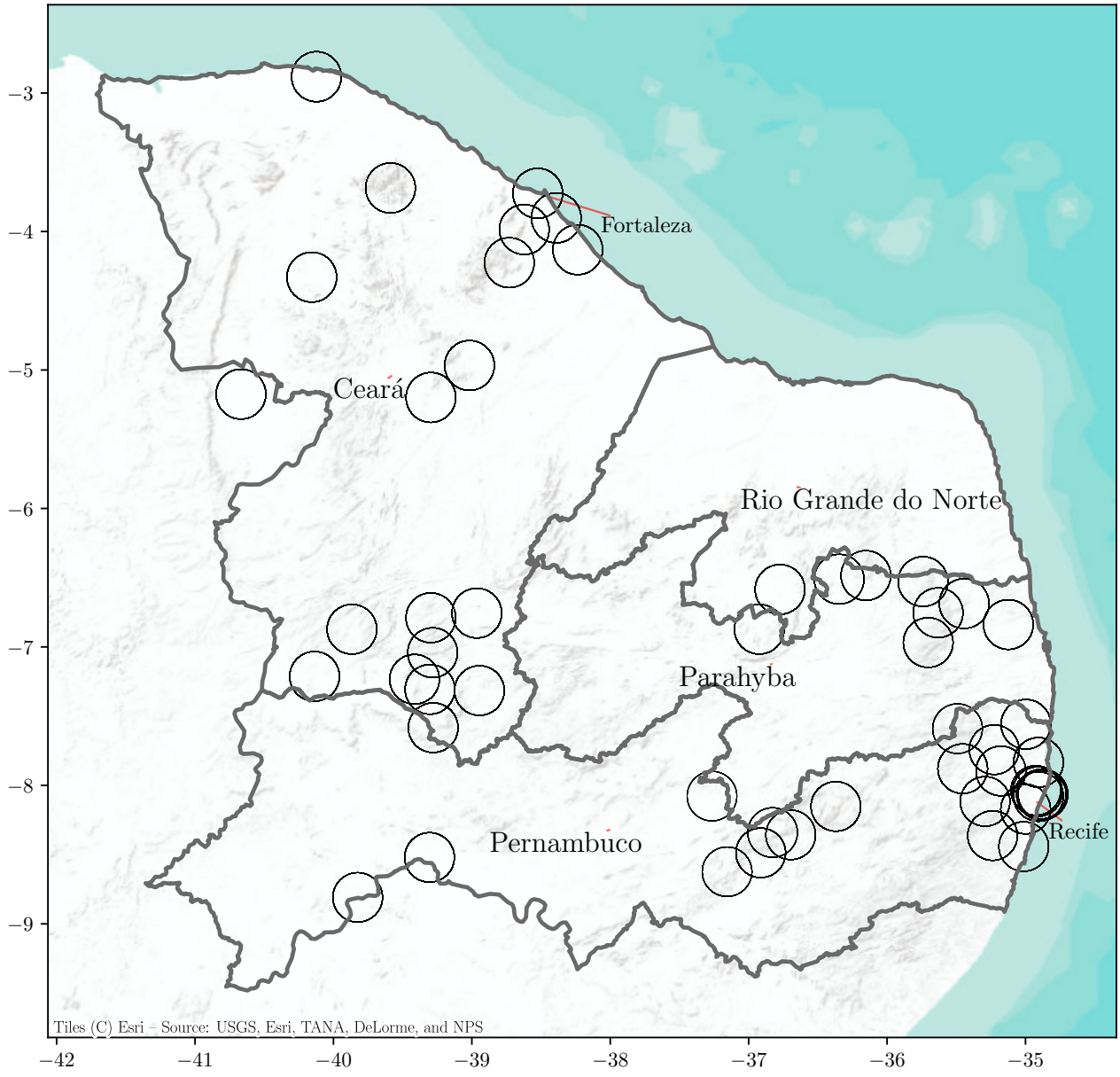
Between 1877 and 1879, the exceptionally strong El Niño Southern Oscillation (ENSO) climate shock triggered precipitation shortfalls across the tropical and semi-arid regions of Northeast Brazil. Widespread crop failures caused by the drought gave rise to a famine (defined here as a shortage of food or purchasing power leading to increased mortality from hunger and disease (Ó Gráda, 2009)), which claimed up to 500,000 lives. The extraordinary death toll during the drought has led scholars to question why the 1877-1879 famine was so severe (Cunniff, 1970; Villa, 2000).

In-line with broader late-19th century food availability decline (FAD) famines (Ó Gráda, 2009), literature on the 1877-1879 drought and famine in Northeast Brazil generally agrees on consecutive harvest failures as the primary cause of the famine (Cunniff, 1970; Greenfield, 1986; Villa, 2000). The accompanying food shortages were aggravated by a combination of poor initial assessment of the drought conditions (Cunniff, 1970; Villa, 2000), inadequate and mismanaged state relief (Greenfield, 1986), exhaustion of coping strategies, and high rural-to-urban immigration. However, the focus of existing research on these broader factors has left fine-grained spatial and temporal distributions of mortality unexplored. Knowing where and when deaths occurred allow for a better understanding of the extent to which famine severity within the disaster region was driven by a few localities, such as places hosting these overcrowded relief camps, and why.

To address this gap, I compile data from Catholic parish burials between 1875 to 1880 for an novel, extensive dataset. It incorporates all recorded burials, aggregated monthly, from parishes in the four most affected provinces by the famine: Ceará (CE), Pernambuco (PE), Paraíba (PB), and Rio Grande do Norte (RN). Figure 1 displays a map of the historical 1872 provinces, and the parishes in them containing burial records. These are further merged into a panel with proximate measure of food availability decline and mediating social factors to verify for patterns of pre-industrial food availability decline famines.

Consistent with a FAD famine, rural mortality decreased whereas its urban counterpart increased. The highest increases were in the parishes surrounding the capitals of Fortaleza and Recife. The concentration of immigrants in the provincial capitals suggests relatively high expectations of state organized relief but a lack of state capacity to provide it. The panel results further confirm a relationship between aridity and higher death rates. This relationship is only significant with the inclusion of proximate controls for migration, namely the distance to capital. The strong role of dryness and distance to capital further reinforces the role of rural harvest failures as a major component of for the food availability decline, indicating that local food production mattered more for mortality than market access to food during the famine.

Figure 1: Select Provinces and Parishes of 1872 Northeast Brazil



Mortality

Previous literature and qualitative sources provide some of the broad strokes in terms of the temporal and spatial distribution of mortality. Increases over the entire region appear to begin in the second half of 1877, and peak somewhere in late 1878 with the outbreak of a smallpox epidemic. Harvest failures from March to July of 1877 already led to widespread destitution, not only from the pre-industrial agrarian societal system, but also as a consequence of the declining cotton and sugar export economy since the 1870s. Unreliable food aid to the hinterlands combined with limited employment opportunities and quick exhaustion of other coping strategies contributed to large-scale immigration into a few regular aid-recipient cities from 1878 onward. Aid commissioners then organized relief camps to facilitate aid delivery and keep the malnourished and ill out of city centers. However, the large agglomerations facilitated the spread of a smallpox epidemic in late-1878 and early-1879, leading to high mortality rates in Ceará and likely the other four provinces as well (Cunniff, 1970; Teophilo, 1922).

The more detailed parish-level data from the Catholic church provides an opportunity to more fully understand the spatial and temporal dimensions of this crisis. As Marcílio (2004) highlights, the church was the main imperial institution responsible for documenting deaths, making them the best late-19th century source for cross-country comparisons. Records were kept at a parish level, where a parish delimited the local churchs administrative responsibilities within a municipality.

A death was transcribed in the parish where it occurred and burial took place. The records consisted of any deceased reported to the pastor of a parish. Name, date-of-death, marital status and partner or parents (Marcílio, 2004) were required to be noted down. As a strongly Catholic nation where over 99.5% of the population was Catholic in 1872, most deaths were expected to have been communicated. Nevertheless, we know the ones of enslaved, freed slaves, children of slaves, and indigenous peoples were under-registered due to negligence, discrimination, and lack of opportunity to report it (Marcílio, 2004). These exceptions should be kept in mind when using this otherwise systematic source of 19th century mortality.

The records gathered consist of over 50.000 deaths gathered from 166 books spanning 58 municipalities presently existing in Brazil. Only municipalities with burial records covering the full 1875-1880 period were selected. Each book consists of the death and where it was buried in the parish. It was thus possible to match the location of the deaths to 54 out of the 194 historical parishes found in the 1872 census. Parishes were then geo-located based on the historical churches responsible for keeping the registers. Their geographic boundaries were not always clearly established, so a roughly defined 20km radius around the chapel was used.

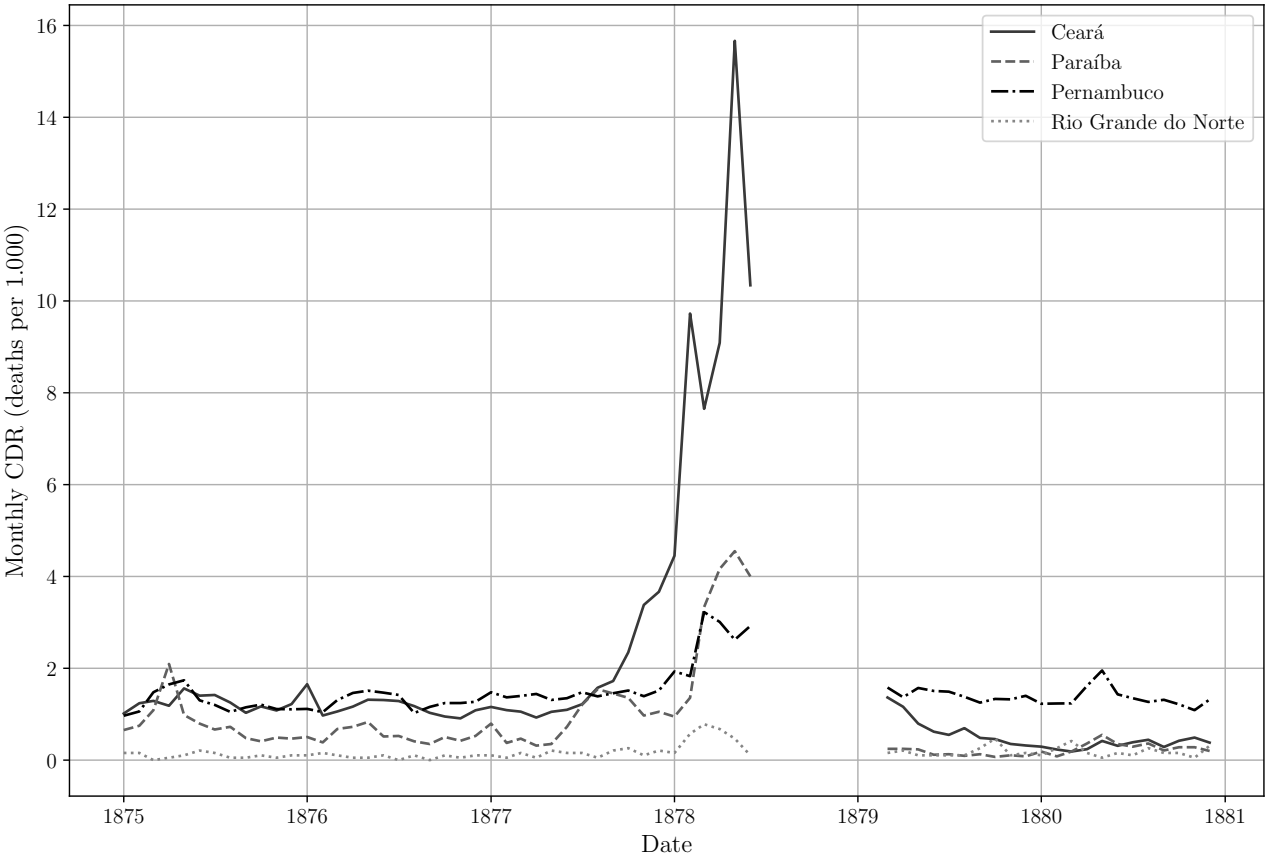
There are also some indications of both idiosyncratic and systematic under-registration. The former occurs during the late-1878 and early-1879 smallpox epidemic, when funerary services provided by the

Church were disrupted (Teophilo, 1922). Corroborated by the low numbers of burials in all provinces except Pernambuco between July 1878 until February of 1879, the period is thus excluded from the analysis.

As for the systematic under-recording, the pre-1877 counts times the number of months in a year reveals a 13,6 annual crude death rate (CDR). This is significantly lower than other late 19th-century estimates of the provincial mortality rates. Despite these issues, its clear that some sample of the mortality was being consistently recorded in every parish. As such, the registers can still be used under the assumption that, throughout the observed period, deaths being recorded in a parish are sampled from the same underlying group. Heterogeneous impacts across different age and gender groups do occur under famine conditions (Ó Gráda, 2009), but fall outside the scope of this article.

Another approach is to look at excess mortality, defined as deaths exceeding the expected baseline, which helps further understand differences in famine severity through mortality rates between parishes. The CDR of a parish is divided by its average pre-1877 rate to get its excess mortality, so the pre-famine baseline excess mortality is 1. However, to mitigate artificially high relative changes in parishes with severe under-recording, parishes in the lower 20th quantile of pre-1877 CDR was excluded. The cutoff was chosen based on a balance between more realistic average CDR and maintaining a representative sample of parishes for analysis. 39 parishes are kept after this adjustment.

Figure 2: Monthly CDR (Deaths per 1.000) by Province Between 1875-1880



Results

A first look at the source in Figure 2 shows how the monthly CDR of each province, calculated as aggregate monthly death counts of each province divided by their 1872 population, varied over 1875 to 1880. A horizontal line at 1.13 is used as reference to the average pre-1877 monthly mortality. All provinces see a relatively stable trend around their initial average mortality rate between 1875 and 1877. Major increase in mortality rates, follow in 1877 and 1878 before quickly declining and converging after 1879 to pre-disaster levels or lower.

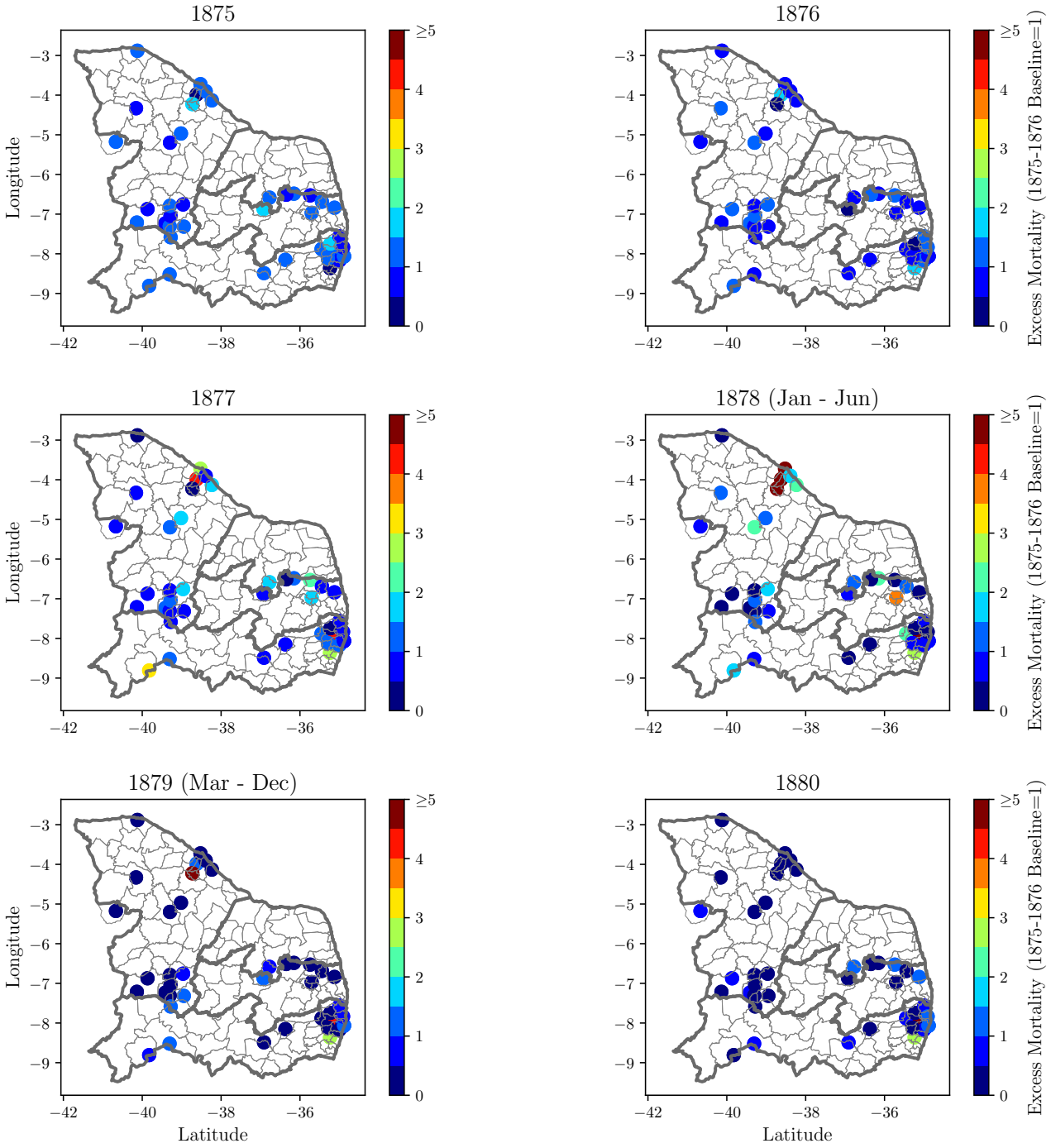
Overall, the provincial mortality rates confirm the 1877-1879 drought had a clear impact on mortality, leading to significant mortality increases in in all provinces. While all provinces were affected, Ceará experienced the most severe impact, followed by Pernambuco.

Moving onto excess mortality, Figure 3's concentration of high surplus deaths in parishes near and within Fortaleza and Recife in 1878 substantiates earlier literature. Inland parishes appeared to have suffered lower excess mortality than these coastal regions. However, migration makes it difficult to clearly distinguish why. Population decline in inland parishes due to migration may have mitigated food availability decline and led to overall lower mortality rates. On the other hand, it can also be leading to a 'false' impression of lower mortality. That is, population declined relative to pre-1877 but monthly deaths remained constant, implying that the true death rates were higher than what is found here. Similarly, high death rates in the parishes closer to the coast may be driven by population increase leading to an increase in death counts. Nevertheless, the extreme growth in death rates in 1878 near Recife and Fortaleza is much higher than the population increase in these areas (Cunniff, 1970; Teophilo, 1922), clearly establishing concentration of famine-related deaths in these parishes.

Given this famine follows patterns consistent with pre-industrial FAD famines, geographic factors were expected to have aggravated harvest failures and thus famine mortality (Ó Gráda, 2009). Food availability in Northeast Brazil was primarily constrained by the potential to grow food locally. The semi-arid and tropical monsoon climates prevalent in Northeast Brazil resulted in a concentrated rainfall period between February and July. As such, climatic dryness and suitability to drought-resistant crops were strong predictors of differences in ability to produce food during drought. More accessible areas near coasts, roads, with less rugged terrain, or close to railways could more easily mitigate food shortages. It is therefore hypothesized that dry areas with limited ability to produce food and access relief were the ones more likely to suffer from high famine mortality.

However, higher mortality in these regions may partly reflect vulnerable populations settling on cheaper land, even as they developed resilience strategies to cope with drier conditions and limited state capacity. Migration makes matters complex, as deaths in destination parishes may be caused by drought impacts experienced elsewhere. Indirectly, however, migration can be approximated based on the known destination of migrants. These were parishes near Recife and Fortaleza, as drought-migrants

Figure 3: Spatial Distribution of Excess Mortality from 1875-1880



sought out the higher relief, employment, and further immigration opportunities.

The dataset combines monthly mortality with parish-level geographic measures of dryness (19011920 average scPDSI), cassava suitability (19601990 rain-fed), ruggedness, and distance to the provincial capital. The former two proximately capture climatic suitability and drought-resistant food cropping, whereas the latter two approximate barriers to efficient state relief. Demographic controls derived from the 1872 census capture population size, proportion enslaved, and the share of agricultural or non-working inhabitants. Monthly death rates are derived by dividing mortality counts by the 1872 parish population.

Drawing on Gallardo-Albarrán et al. (2021)'s model, the specification regresses parish-level mortality rates on an interaction between an 18771879 drought indicator and the geographic variables, controlling for sugarcane suitability, demographic factors, and population age structure.

More plausibly, the relationship between parish mortality and the geographic factors related to FAD and food access evolved during the drought. The equation:

$$\begin{aligned} MortalityRate_{i,t} = \sum_{t=1}^{72} \beta_t (Dryness_i \cdot 1_t) + \sum_{t=1}^{72} \kappa_t (CassavaSuit_i \cdot 1_t) + \\ \sum_{t=1}^{72} \delta_t (Ruggedness_i \cdot 1_t) + \sum_{t=1}^{72} W_t (Controls_i \cdot 1_t) + \gamma_t + \lambda_i + \epsilon_{i,t}, \end{aligned} \tag{1}$$

is used evaluate how geographic factors affected mortality over the 1877-1879 drought months. Coefficients $(\beta_t, \kappa_t, \delta_t)$ estimate the mortality levels in parishes for different levels of dryness, cassava suitability and ruggedness for each month of each year t. December of 1876 ($t = 24$) serves as the benchmark year for the estimates, and the dummy 1_t interacted with the geographic factors and controls expresses the month-year combination.

The results from the first specification, available upon request, emphasize the role of dryness as the geographic factor with a consistent positive effect on mortality during the 1877-1879 drought. This effect becomes prominent once distance to Recife or Fortaleza is accounted for, and weakly significant at a 90% confidence interval after accounting for the proportion of the population in a vulnerable employment and the proportion of slaves in a parish. After account for all factors, a unit increase in the scPDSI level of a parish suggests a 3.662 to 4.624 increase in average crude mortality rates levels in the drought years. Cassava suitability and ruggedness, on the other hand, are too imprecisely measured to draw conclusions.

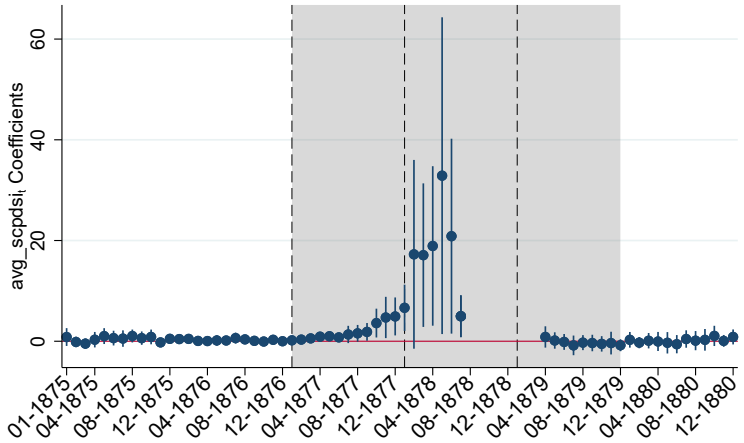
Turning now to the estimation results for equation (2), Figure 4 displays the result of the changes in coefficients over time. Time t values are expressed in terms of month-year for clarity. Evidence of pre-drought common trends are seen by from the consistent zero estimated impact of dryness, cassava suitability, ruggedness, and distance to capital on mortality prior to the drought. During the drought, however, it's possible to see that dryness increasingly and significantly contributes to mortality from

August 1877 until March of 1878, with the exception of January 1878 where the coefficient estimates are not significant. It's estimated effect declines quickly and is no longer significant after May 1878.

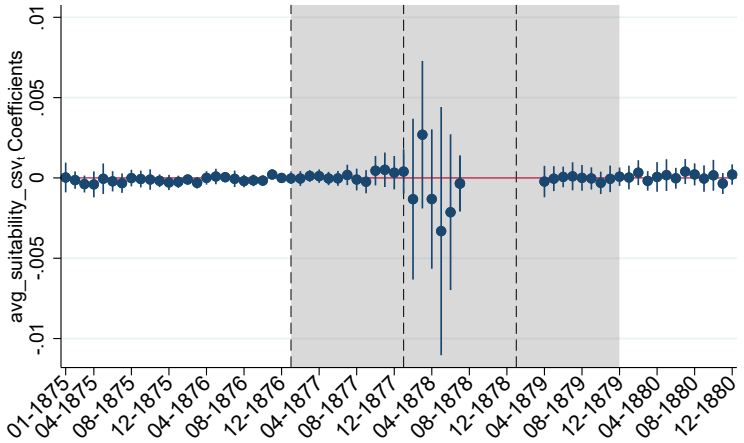
The results were also robust to selective control omission, pre-1878 restricted analysis, Conley spatial errors, changes to parish boundaries, excess mortality as a dependent variable, and outlier exclusion. They can be provided separately upon request to the author.

Figure 4: Dryness, Cassava Suitability, Ruggedness, and Distance-to-Recife-or-Fortaleza Effects on Mortality

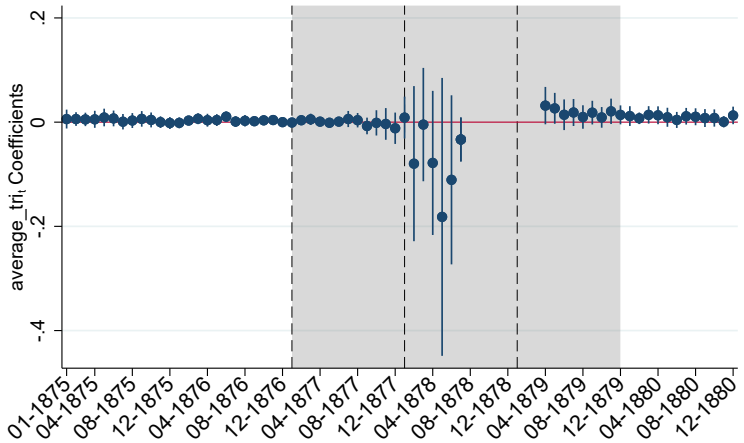
(a) Dryness



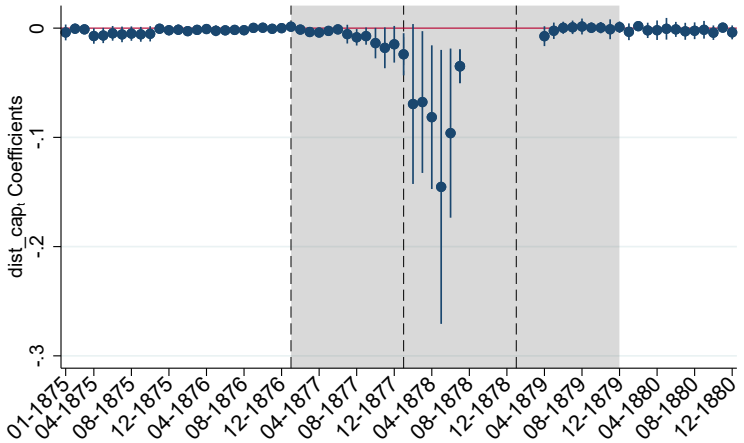
(b) Cassava Suitability



(c) Ruggedness



(d) Distance-to-Recife-or-Fortaleza Effect on Mortality



Discussion

The findings are consistent with dryness-induced harvest failures resulting in higher mortality up until 1877. I those years, dryness significantly relates with mortality whereas distance to capital does not, suggesting a direct channel of drought on mortality through harvest failures. After 1878, however, distance to capital turns significant. This is interpreted as remote locations being depopulated by emigration, and experiencing lower mortality, where the reverse is true near capitals. For dryness and migration to have such an impact on mortality, despite the omission of the smallpox epidemic, implies much more widespread economic activity than expected from the *serto* region. Cotton explains partly why it was heavily settled in the 1800s, but not necessarily why it remained so populated up until the drought.

Tying in with the broader literature, the findings that both dryness and migration strongly explain the incidence of mortality points towards a similar situation to the one outlined by Roy (2016) in India. He notes how state actions do not fully align with those of an underdeveloped pre-industrial state, as evidenced both by the large relief expenditures and active organization of relief commissions across the drought region to attend the disaster-stricken migrants.

What makes the case of late 19th century Brazil interesting when compared to India is the sudden engagement of authorities with a previously ignored *sertão* population. As emphasized by De Castro et al. (1952), the inhabitants of this semi-arid region, the *sertanejos*, were marginalized populations who could subsist in the semi-arid region with higher living standards than in the tropical coast - with the exception of drought years. The 1877-1879 drought highlighted a major shift in their relationship with the state, where the ability of local, provincial and national governments to relieve this population became a central issue. It remains unclear whether drought-induced migration was driven by the expectations that state-sponsored relief allowed for a better higher chance of survival than pursuing agricultural work further inland, or if migrants were unable to migrate further and forced to rely on whatever means were available locally. As overall amount of relief was nevertheless insufficient to alleviate the food shortages, the disaster was perhaps the last major FAD famine in the Americas.

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For the complete list of references from the dissertation chapter underpinning this text, please contact the author.

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