

Long-lasting drought and adolescent socioemotional skills

Seca de longa-duração e habilidades socioemocionais de adolescentes

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Abstract

Socioemotional skills are key determinants of adult life outcomes. Significant changes in economic conditions can affect the formation of such skills, especially at more vulnerable ages. In this paper, we study how a long-lasting drought event is associated with adolescents' accumulation of socioemotional skills. Between 2012 to 2015, the Brazilian semi-arid region was exposed to a long-lasting exogenous drought. Comparing students exposed versus not exposed to the drought in the state of Ceará, we found evidence that the drought episode significantly reduced students' conscientiousness skills, a skill related to persistence, organization, and focus. We confirmed these results by investigating the facets associated with conscientiousness, socioemotional traits and other related outcomes, such as student aspiration. This paper showed that a steep increase in drought can be correlated with students' socioemotional skills, especially at sensitive ages of socioemotional formation.

Keywords

socioemotional skills, Brazilian semi-arid, drought shock.

JEL Codes I2, I28, I24.

Resumo

As habilidades socioemocionais são determinantes-chave dos resultados da vida adulta. Mudanças significativas nas condições econômicas podem afetar a formação de tais competências, especialmente em idades mais vulneráveis. Neste artigo, estudamos como um evento de seca de longa duração afetou o acúmulo de habilidades socioemocionais dos adolescentes. Entre 2012 e 2015, a região semiárida brasileira foi exposta a uma seca exógena de longa duração. Comparando alunos expostos e não expostos à seca no estado do Ceará, encontramos evidências de que o episódio da seca reduziu significativamente as habilidades de conscienciosidade dos alunos, uma habilidade relacionada à persistência, organização e foco. Confirmamos esses resultados investigando as facetas associadas aos traços socioemocionais de conscienciosidade e outros resultados relacionados, como as aspirações dos alunos. Este artigo mostrou que um aumento acentuado da seca pode afetar as competências socioemocionais dos alunos, especialmente em idades sensíveis de formação socioemocional.

Palavras-chave

habilidades socioemocionais, semiárido brasileiro, choque de seca.

Códigos JEL I2, I28, I24.

1 Introduction

Socioemotional skills influence a wide range of individual and societal outcomes (Heckman *et al.*, 2019; Almlund *et al.*, 2011). Such skills can be defined as the individual capacities that are manifested in consistent patterns of thoughts, feelings, and behaviors, that can be developed through formal and informal learning experiences, and that influence important socio-economic outcomes throughout the individual's life, like educational attainment, wages, job performance, and health outcomes (OECD, 2017). Recent evidence documents rising returns of non-cognitive skills in comparison with cognitive skills (literacy and numeracy) in the 2000s (Edin *et al.*, 2022; Deming, 2017), suggesting the growing importance of these skills for the labor market. A key factor in socioemotional skill formation is economic conditions. Changes in economic variables can drastically affect the accumulation of non-cognitive skills, and the magnitude of this effect depends on the individual's stage of socioemotional development (Kankaraš and Suarez-Alvarez, 2019). Particularly, one vulnerable group is adolescents¹. Exposure to larger changes in economic conditions during this critical period of development can lead to socioemotional deficits that have consequences for their future well-being.

Despite a large number of evidences about the impact of natural disasters on cognitive skills or schooling, few studies have addressed the effect of such events on non-cognitive skills; exceptions are Adhvaryu *et al.* (2019); Akee *et al.* (2018); Mehra *et al.* (2019); Nordstrom and Cotton (2020). This paper attempts to contribute by investigating the correlation of a long-lasting drought shock on Brazilian students' socioemotional traits².

We follow a widely used approach that exploits variation in local rainfall as a proxy for local exposure to drought (Shah and Steinberg, 2017; Burke *et al.*, 2015; Corno *et al.*, 2020). However, differently from the standard approach that considers short-run shocks (one year or season), our drought event corresponds to a persistent period of below-normal precipitation. From 2012 to 2017, the Northeast region of Brazil was affected

1 Adolescents have several behavioral biases that affect investments in human capital and can be intensified with greater and unexpected changes in the economic conditions, see (Steinberg, 2014; Bursztyn *et al.*, 2019; Lavecchia *et al.*, 2016).

2 We will consider the following terms interchangeable: socioemotional skills, socioemotional traits, personality traits, and non-cognitive skills.

by an unprecedented and long-lasting dry episode caused mainly by three exogenous factors: an abnormally high sea surface temperature (SST), the successive events of La Niña (2010-2011) and El Niño (2015-2016). The combination of these factors produced a period of six consecutive years of drought in the region³. We exploit this unique and exogenous episode to estimate its association with adolescents' socioemotional traits.

To measure the socioemotional traits, we used a survey applied to secondary students in Ceará, a Northeast state of Brazil, in 2015. This instrument, called the SENNA instrument, measures the five socioemotional traits of the Big Five inventory: Conscientiousness, Openness, Extroversion, Agreeableness, and Emotional Stability. It is important to highlight the scarcity of data sources that evaluate the socioemotional competencies of the Brazilian population, which creates difficulties in formulating adequate public policies. In this context, SENNA stands out as a unique and valuable dataset to assist subnational governments in improving educational outcomes. The instrument was developed by a group of specialists, and its statistical properties were extensively tested (Primi *et al.*, 2016b, a, 2021). The SENNA instrument addresses key issues related to self-reported surveys, such as acquiescence bias, reference bias, and student attention during the survey application. These issues are particularly important in developing countries like Brazil.

We compare differences in the socioemotional skills of students that lived in municipalities highly exposed to droughts relative to students who lived in municipalities not exposed to droughts. Our measure of exposure to drought shock is related to the proportion of months that a municipality records a low precipitation level according to the Standard Precipitation Index (SPI). We define the treated municipalities as those above the 75th percentile of the distribution of months of the dry period. We set the treatment this way to avoid problems related to temporal variations in dry periods over the years⁴. Although our estimates do not represent a causal relationship, we adopted several empirical strategies, such as sample selection and the addition of controls that may suggest a causal effect of drought shock on socioemotional skills.

3 The last time a similar phenomenon occurred was over eighty years ago Marengo *et al.* (2018).

4 In the robustness section, we test variations of the definition of occurrence of drought events.

Our results suggest that long-term drought episodes are adversely correlated with conscientiousness skills, which is related to the ability that helps to focus attention and behavior on the relevant things when we need to meet standards. The conscientiousness skill potentially affects long-term individual outcomes, like college attendance, high school or university graduation, and others associated with persistence and focus on long-run objectives (Heckman and Mosso, 2014; Almlund *et al.*, 2011; Heckman *et al.*, 2019). Other socioemotional skills are negatively affected; however, they are not statistically significant.

Besides the main results, a special feature of the SENNA instrument is the possibility to decompose the socioemotional traits in their facets, allowing us to understand the association with the long-lasting drought shock in more detail. For instance, the construct of conscientiousness can be decomposed into four facets: Focus, Determination, Organization, and Persistence. We estimate the correlation of drought exposure on these facets using a similar empirical strategy. We find that students' focus, organization and persistence are negatively associated with drought shock. Student determination is also negatively and statistically significantly affected; however, the effect size is smaller than other Conscientiousness facets.

We attempt to explain the larger association between drought shock and conscientiousness by the student's aspiration. Dalton *et al.* (2016); La Ferrara (2019) argue, theoretically, that economic shocks, such as droughts, can reduce the marginal benefit of students making an effort, consequently affecting their aspirations about the future. As the drought persists over at least four years (2012-2015), these two effects, the reduction in the marginal benefit of effort and the decrease of student aspiration may impact the students' effort, potentially modifying their personality traits during adolescence⁵. Thus, student aspiration is expected to be affected by drought shock as well. We re-estimate the association of the drought with measures of student aspirations. We find evidence that drought shock adversely correlates with the students' aspiration to continue studying during and after high school.

5 Recently, Dweck (2017) developed a psychological theory that explains these mechanisms. According to it, individual goals (aspirations in economic literature) are the origin of the formation of personality traits.

The literature has documented a large number of studies investigating the effects of droughts on human capital formation. Most research has explored the impacts of drought on infant mortality and birth health outcomes, showing that negative rainfall shocks are strongly associated with lower birth weights and higher infant mortality (Rocha and Soares, 2015; Lin *et al.*, 2021; Kudamatsu *et al.*, 2012). These works highlight how in utero conditions affect individual outcomes during adulthood, thereby evidencing the need for interventions during critical periods for human development, such as childhood and adolescence (Cunha and Heckman, 2009). In the same vein, a body of studies has explored the effects of drought on the cognitive abilities of children and adolescents (Branco and Féres, 2018; Nordstrom and Cotton, 2020). For instance, Ortiz (2022) demonstrates the existence of a significant negative impact of natural disasters on the acquisition of cognitive skills in students studying in rural areas of Colombia, which more strongly affects economically vulnerable students.

The main contribution of our work is to show evidence of the association of the droughts with human capital formation in a specific age interval (*i.e.*, adolescence) in a poor region of Brazil. Cunha and Heckman (2009) emphasize the importance of non-cognitive skills in the development of human capital and how these skills are fundamental for educational, occupational, and social success. Our paper contributes to this literature by showing that adverse events, such as droughts, can impair these non-cognitive skills. In this literature, drought events are interpreted as an income shock to the agricultural sectors (Shah and Steinberg, 2017; Björkman-Nyqvist, 2013), affecting the ability of families to invest in the development of their children's skills.

In this sense, our results suggest that public policies should consider both the economic and psychosocial impacts of droughts to mitigate their negative effects on human capital formation. Furthermore, in line with the arguments of Cunha and Heckman (2009), we emphasize the need for interventions that not only focus on cognitive skills but also strengthen non-cognitive skills, which are essential for the holistic development of individuals and for reducing inequalities in opportunities.

Our article is also included in the literature on the malleability of socioemotional traits, particularly during adolescence. Several studies suggest that socioemotional skills are malleable at specific periods in a student's life, such as childhood (Kautz *et al.*, 2014; Alan *et al.*, 2019). Other types

of shocks also affect personality traits during adolescence, such as health shocks (Elkins *et al.*, 2017) or test score rankings (Pagani *et al.*, 2021). Our paper contributes to this literature by showing that critical changes in economic conditions during adolescence impact the development of socio-emotional skills.

Lastly, our paper also contributes to the literature on the economic impacts of natural disasters (Takasaki, 2017; Cavallo and Noy, 2011; Oliveira, 2019). Most of the economic literature focuses on the negative effect of extreme climatic shocks on the agricultural sectors (Deschênes and Greenstone, 2012; Burke and Emerick, 2016). Adaptation strategies, such as changing crop mixes, investing in irrigation, and reallocating labor (Colmer, 2018; Aragón *et al.*, 2021), can mitigate the effect of natural shocks. Our research highlights that, in addition to the direct economic impacts, natural disasters also affect socioemotional accumulation. Thus, our findings provide insights into the non-agricultural impacts of natural disasters.

Besides this introduction, section two discusses the drought that occurred in Northeast Brazil between 2012 and 2017. Section three presents the data and the empirical strategy adopted. In turn, section four presents the main results, the heterogeneous analysis, and the correlation of the drought on student aspirations. Section five discusses the main conclusions.

2 Background

2.1 Study area and the long-lasting drought in the Brazilian semi-arid region (2012-2017)

The semiarid region located in the Brazilian Northeast is characterized by low socioeconomic factors such as high rates of illiteracy, low-income levels, and social exclusion, among others. In climatic terms, this region is exposed to the observed extremes of climate variability, mainly droughts, that produce land degradation and desertification. The combination of these characteristics makes this region one of the world's most vulnerable territories to climate change (IPCC, 2014).

Drought is a natural and recurrent phenomenon in this Brazilian region, resulting in significant material and human damage and socioeconomic loss. Dry episodes in semiarid areas are often associated with large-scale phenomena such as El Niño and La Niña events or related to an intense meridional sea surface temperature (SST) gradient over the tropical Atlantic (Marengo *et al.*, 2018). Although droughts are frequent in the region, persistent periods of low rainfall (more than three consecutive years) are very rare.

From 2012 to 2017, the Brazilian semi-arid region was impacted by a long-lasting period of low precipitation that caused damage throughout the region. This prolonged drought period was caused by a combination of three main factors that happened in sequence during this period. First, the La Nina, which began in 2012, was responsible for the below-average rainfall reduction during the years 2012 through 2014. Earlier, between 2009 and 2010, the Atlantic Inter-Tropical Convergence Zone (ITCZ) migrated to an abnormal position, indirectly contributing to a drop in rainfall in the semi-arid region (Rodrigues and McPhaden, 2014; Marengo and Bernasconi, 2015)⁶. Both events were followed by El Nino, 2015-2016, which extended the dry period until 2017. The combination of these three factors is extremely rare, and the last time a similar drought occurred in the region was more than eighty years ago (Marengo *et al.*, 2018; Santana and Santos, 2020).

The state of Ceará, the study area, is located in the Northeast region of Brazil, with approximately 87% of its total area situated in the semiarid region. On average, the population size of the municipalities is 46,000 inhabitants, with approximately 44% of the population residing in rural areas. The average poverty rate is approximately 68% of the municipalities' population, the average per capita income is around R\$ 262.50, and the average unemployment rate is 7.12%, pursuant to the 2010 Demographic Census.

According to the Digital Atlas of Disasters in Brazil, between 2012 and 2017, there were 966 records of disaster occurrences (emergency situation decrees) due to drought in the state of Ceará, affecting about 9.72 million people and causing an estimated loss of approximately 15.9 billion reais. During this period, 90% of the municipalities' revenues in Ceará came

6 An anomalously northward/southward position of the ITCZ, determining less/more rainfall in Northeast. These mechanisms induce and intensify the precipitation in the region.

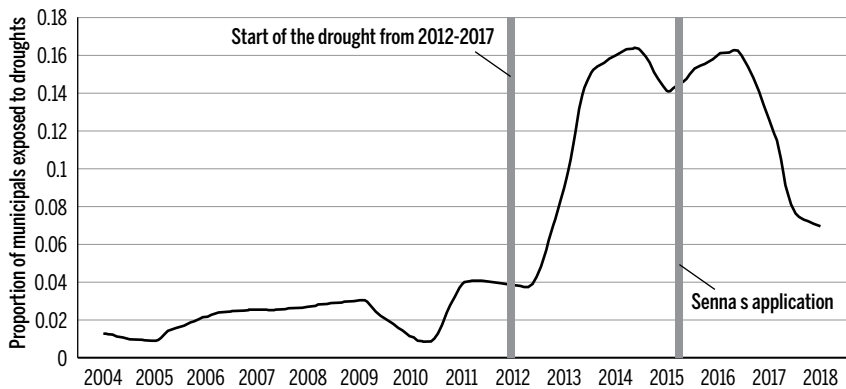
from government transfers, which also requested federal public assistance to mitigate the impacts of the prolonged period of low precipitation, including special lines of credit for small farmers and distribution of water by trucks (*carros pipa*) in rural and urban areas.

In terms of economic activity, the services/trade sector accounted for about 46% of the total GDP between 2012 and 2017, while the manufacturing industry and agriculture represented approximately 17% and 4.5%, respectively, of the municipalities' total production during the period. Figure A1, in the Appendix, shows the evolution of the average per capita GDP and the participation of the agriculture, services/trade, and industry sectors in the municipalities of Ceará from 2008 to 2019. We observe that during the prolonged drought period (2012-2017), there was a relative decline in the participation of agriculture in the municipalities' GDP, highlighting the effects of the long-term drought on agricultural activity.

In this study, we observed the socioemotional skills of students in 2015, representing four consecutive years of drought exposure (2012 to 2015). The persistence and intensity of this episode were unexpected by students, despite the region being constantly affected by droughts. To understand the long-lasting drought variation in the state of Ceará, we computed the moving average of the last 48 months (four years) of the proportion of municipalities exposed to drought according to our main drought measure, based on precipitation levels. Figure 1 shows that the number of municipalities classified as in a state of drought, considering the average of the last 48 months, increased to 13 percentual points in 2015. This means that after 2012, the number of municipalities that experienced some degree of drought rose rapidly. Since 2004, students had not been exposed to such a long-lasting period of drought as from 2012 to 2015.

The analysis of this phenomenon is interesting for several reasons. First, it was an exogenous event, potentially caused by global climate anomalies. Climate scientists expect such events to occur more frequently in the coming years as the earth's temperature rises. Then, this paper contributes to explaining the potential correlation of the long-lasting drought periods on students' socioemotional skills. Second, unlike short-term climate shocks, this drought lasted more than six years (2012-2017) and promoted a large economic loss for the region. This event is useful for exploring how individuals adapted to enduring climate episodes and whether adaptation prevented its impact on students' socioemotional skills.

Figure 1 **Moving average of the proportion of municipalities exposed to drought (48-months)**



Source: Elaborated by the authors.

Note: Figure 1 presents the proportion of municipalities exposed to drought during the years 2004 through 2017. This proportion is calculated as the moving average of the last 48 months (last four years). Drought is classified according to the Standardized Precipitation Index (SPI). The lines in red denote the official drought period in the region according to the Brazilian Ministry of Integration.

3 Data and Empirical Strategy

3.1 Data

3.1.1 Socioemotional traits

To measure socioemotional skills, we used a specific instrument applied to all students in the state of Ceará in 2015. The students were in the 10th grade, corresponding to the first academic year of secondary school. The instrument, called SENNA, was developed by the Instituto Ayrton Senna, a Brazilian civil society organization focused on citizen agency and public service provision.

The SENNA instrument consists of a self-report questionnaire (57 items) that measures socioemotional skills related to the Big Five personality inventory⁷. Socioemotional skills refer to the ability to regulate one's

7 The nomenclature of constructs in the SENNA Instrument is different from the conventional Big-Five constructs, although the instrument measures the similar socioemotional as-

thoughts, emotions, and behavior, and can be divided into five constructs: Openness, Conscientiousness, Extraversion, Agreeableness, and Emotional Stability (also called Neuroticism). Openness is related to creativity, curiosity, and artistic interest. Conscientiousness is associated with persistence, organization, determination, and efficiency. Extraversion is related to being outgoing, having social initiative, and having enthusiasm. Agreeableness, in turn, is correlated with compassion, trust, and respect for the other. Finally, emotional stability is connected with the modulation of stress and frustration.

The original sample consists of 109,606 (86% of the total secondary students in 10th grade in 2015) students. However, due to sample constraints, we analyze a sample that contains nearly 20,000 students. The instrument also collects demographic and socioeconomic information such as gender, age, race, and mother's education.

Despite widespread use to measure socioemotional traits, self-report instruments are limited in several ways. The main limitation associated with such instruments is the reference bias (Heckman *et al.*, 2019) caused by students' different interpretations of the questions⁸. The SENNA instrument attempts to reduce the reference bias by applying vignettes that improve the performance of surveys. The vignettes anchor the student's perception and reduce the problems related to comparing levels of personality skills across different groups (Primi *et al.*, 2016a). The SENNA version used in this paper contains 20 vignettes, four for each socioemotional trait.

Another important issue related to self-reported instruments is the desirability bias. Students can answer the questions according to what they expect to be considered socially desirable. The construction of the SENNA instrument considered the possibility of desirability bias. For this reason, several comparisons were made of the instrument's responses with other variables that are associated with socioemotional skills but not with desirability bias, such as performance and school dropout. The results did not indicate the presence of desirability bias (Santos and Primi, 2014; Santos *et al.*, 2017).

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 pects. We recognize the relevance of SENNA nomenclature; however, we prefer to adopt the conventional names of Big-Five to facilitate the exposition.

8 For instance, poor students may interpret the concept of persistence differently from non-poor students because they have different notions, promoted from their experiences, about what it means.

Particularly, in developing countries the self-reported survey presents high acquiescence bias (Laajaj *et al.*, 2019; Laajaj and Macours, 2021), in which students tend to answer all items with a similar response pattern. The SENNA instrument has 13 items with reverse meaning, that is, where answering "I totally agree" to a certain statement, for instance, can indicate a negative aspect of the behavior. These items allow us to identify the presence of and adjust the estimates for acquiescence bias. In addition, the SENNA survey includes two items that measure student attention while completing the survey. These items ask students to respond to a specific answer to a given question⁹. This item type identifies whether students read the questions before answering them. We excluded from the sample the students who wrongly answered both verification items.

The psychometric characteristics of the SENNA instrument were tested and presented a well-defined factor structure, and high internal consistency¹⁰, and external validity when related to measures of performance in Portuguese and math test scores (Primi *et al.*, 2021). In summary, the SENNA instrument is a reliable tool for measuring the socioemotional skills of students in low-income countries such as Brazil.

3.1.2 *Weather data*

Our measure of drought exposure is derived from the monthly precipitation rate. We exploit ground station data provided by the Department of Agriculture and Water Supply of the Government of Ceará. In Ceará, there are 274 meteorological stations representing coverage of almost 1.5 stations per municipality. These stations have been providing highly accurate measurements of the weather at daily frequency since 1970. To avoid bias due to the creation and deactivation of stations over time, we restricted the sampling to start in 1991.

To measure the drought intensity, we estimate the Standard Precipitation Index (SPI), which is used for detecting and characterizing meteorological droughts. The SPI indicator, developed by McKee *et al.* (1993), measures precipitation anomalies at a given location, based on a compari-

9 For example: *In this question, mark option 3.*

10 Cronbach's alpha, respectively: Openness (0.90), Conscientiousness (0.94), Extraversion (0.98), Agreeableness (0.98), and Emotional Stability (0.88).

son of observed total precipitation amounts for an accumulation period of interest¹¹ with the long-term historic rainfall record for that period. The historic record is fitted to a probability distribution (the gamma distribution), which is then transformed into a normal distribution such that the mean SPI value for that location and period is zero.

Our historical records from monthly precipitation correspond to 26 years, from 1991 to 2017. We aggregate the precipitation records at the average municipal level. We complement the weather data with average municipal temperature obtained from Global Climate Monitor, which exploits multiple climate data sources and provides georeferenced data of the global climate (Camarillo-Naranjo *et al.*, 2019).

3.1.3 Additional data

We also use additional data from the Department of Agriculture and Water Supply to measure the water coverage, and several economic activity variables from *Instituto Brasileiro de Geografia e Estatística* (IBGE) to assess the economic impact of the long-lasting drought in Ceará. We also used data from the *Instituto de Pesquisa e Estratégia Econômica do Ceará* (IPECE), a local governmental agency of statistics. Lastly, the Secretary of Basic Education of the State of Ceará (SEDUC-CE) shared a unique student ID that allowed us to identify students who migrated to different schools during the drought period. We used this dataset to address potential threats to the empirical strategy. All control variables at municipal level were measured in 2010, before the beginning of drought.

3.2 Sample restrictions

The original database contains approximately 109,606 first-year high school students from Ceará, representing 86% of the students in this grade. Given the nature of the climate phenomenon we are analyzing, it is necessary to introduce some restrictions in the sample.

11 We focus on SPI 12 months that are more suitable for long-term droughts.

We excluded the five largest Ceará municipalities: Fortaleza, Caucaia, Sobral, Maracanaú, and Juazeiro do Norte. These municipalities are generally more urban and have a better-quality water supply infrastructure than the other municipalities¹². This may moderate the impact of drought on students, generating noise in the estimates. The sample was reduced by 36,699 students.

The climate event did not occur linearly over time. That is, municipalities may have been affected differently (higher or lower intensity of drought) in different years between 2012 and 2015. Thus, students who were cumulatively equally exposed to drought, in terms of months of exposure, may have different effects depending on when the municipality was affected. To minimize this problem, we chose to compare students in highly drought-exposed municipalities against students from municipalities that were not exposed to drought. We define the total exposure to drought of a municipality i , $TotalExposure_i$, as the number of months from 2012 to 2015 (48 months) that the municipality presented SPI below -1 , which represents the presence of moderately dry month¹³, that is:

$$TotalExposure_i = \sum_{m=1}^{48} I\{SPI_{im} \leq -1\} \quad (1)$$

where $I\{SPI_{im} \leq -1\}$ is an indicator function that assigns 1 if SPI is below -1 to the municipality i in the month $m = 1, \dots, 48$. Thus, municipalities are considered as highly exposed to drought (treated) as those that are above the 75th percentile of the $TotalExposure_i$ distribution. The municipalities in the control group are the municipalities that were not exposed to drought between 2012 and 2015, i.e., $TotalExposure_i = 0$. The restriction to high and low drought exposure municipalities removes an additional 28,050 students from the sample.

Additional sample restriction refers to students who wrongly answer the two attention items and are consequently excluded. The SENNA survey includes two items that measure the student's attention while filling out the instrument. These items ask students to respond to a specific answer to a given question. This type of item identifies whether students

12 In the appendix, we report the main estimation including those municipalities. The results are quite similar. See Table A7.

13 The SPI classification for drought is: $SPI \in [0; 0,99]$ "near normal"; $SPI \in [-1; 1,499]$ moderately dry; $SPI \in [-1,5; 1,99]$ severely dry, and $SPI \leq 2,0$ extremely dry.

read the questions before answering them and is particularly important in long self-report instruments such as the SENNA¹⁴.

The final sample consists of 23,354 students, 14,156 belonging to the control group and 9,198 to the treaty group, arranged in 110 municipalities (59% of the total number of municipalities in Ceará) and 250 high schools (38% of the total number of schools in 2015).

3.3 Empirical Strategy

The empirical analysis consists of comparing students in highly exposed drought municipalities relative to less exposed drought municipalities. Thus, to test the association of long-lasting drought on students' socio-emotional skills, we estimate the following equation:

$$y_{ims} = \alpha_0 + \alpha Treat_m + \theta'_1 X_{ism} + \theta'_2 X_m + \varepsilon_{ims} \quad (2)$$

where y_{ims} is the socioemotional measure of student i , in the school s , in municipality m . We focus our attention on the five socioemotional constructs: Openness, Conscientiousness, Extraversion, Agreeableness, and Emotional Stability.

The variable $Treat_m$ is a dummy variable assigning one to highly exposed municipalities and zero to municipalities not exposed to drought. We measured drought exposure using the proportion of months, from 2012 to 2015, in which a municipality experienced a low precipitation anomaly. The monthly anomalies are measured using the Standard Precipitation Index (SPI) classification. We chose to consider municipalities that had at least a moderate drought to avoid noise.

The treated municipalities are those that have high exposure to monthly dry episodes (above the 75th percentile), and the students in the control group are those in municipalities that were not exposed to drought in any month from 2012 to 2015. The parameter of interest is α , which captures the standardized deviation of socioemotional skills associated with municipal-specific variation in exposure to drought.

14 In the appendix, see Table A1, we compare the characteristics of students that answered and did not answer correctly the attention items using normalized difference (ND). Only repeated and girls' variables present significant differences between two groups. In our main specification, we control for both factors, and we test the presence of heterogeneous effects in those variables in section 4.4.

The vector X_{ism} is a set of student's pre-determined characteristics, such as gender, mother's education, racial status, age, and a variable indicating if the student attended pre-school. In turn, X_m represents a vector of municipal pre-determinant controls, measured before the drought, such as the proportion of elderly, local inequality (Gini Index), average temperature (the year 2015), and municipal Human Development Index (HDI_m). The former variable captures the municipal development factors. The proportion of elderly people and local inequality may affect the distribution of educational public spending. Municipalities with large elderly populations tend to focus their spending more on health than education. In addition, Colmer (2018) shows the importance attributed to rainfall for agricultural production may be overestimated if we omit a temperature variable. With the exception of the temperature variable, the resting variables were measured in 2010, prior to the drought period. In the robustness check, we also add the square of these local variables to capture the potential nonlinearities.

Following Hsiang (2010); Colmer (2018), we assume that the ε_{ims} error term is heteroskedastic and serially correlated within the municipality. Drought shocks have specific effects on each municipality, even if they are of the same magnitude, which can generate heteroskedastic and serial correlation in errors within the municipalities. We then clustered the standard error estimates at the municipal level.

The key identification assumption refers to the exogeneity of municipalities highly exposed to drought shock in relation to students' unobserved characteristics. We checked this assumption by comparing whether exposed students differ in terms of ex-ante socioeconomic factors from control students. Particularly, we test the overlap between the treated and control groups to verify whether these groups are balanced across a wide set of pre-treatment observable characteristics. Our empirical specification is a linear regression that can be sensitive when the covariates between the treatment and control groups are limited. We check for overlap using normalized (or standardized) differences (Rubin, 2001). The normalized difference (ND) for a continuous variable is given by:

$$ND = \frac{(\mu_t - \mu_c)}{\sqrt{\sigma_t^2 + \sigma_c^2}} \quad (3)$$

where μ_t and σ_t^2 are the mean and variance of treated group, and μ_c and σ_c^2 are the mean and variance for control group. Imbens and Wooldridge

(2009) suggests that the normalized difference should be below 0.25 to consider the sample balanced. The Table 1 presents the overlap difference estimates. We observed no difference greater than 0.25, suggesting that students from non-drought-affected municipalities constitute a good control group for the treatment group.

Table 1 **Overlap between treated and control groups**

Variables	Treated		Control		Balance Std-diff
	Mean	Variance	Mean	Variance	
Racial Status					
White	0.2007	0.1604	0.1985	0.1591	0.0055
Brown	0.0625	0.0586	0.0620	0.0581	0.0023
Black	0.5847	0.2429	0.5935	0.2413	−0.0178
Demographic Factors					
Age	97.238	15.666	96.394	14.124	0.0692
Girls	0.5897	0.2420	0.5774	0.2440	0.0250
Residents in household	38.747	30.838	39.242	31.865	−0.0279
Prior Education					
Preschool	0.8165	0.1499	0.8290	0.1418	−0.0328
Kindergarten	17.731	0.4579	17.729	0.4608	0.0003
Repeated	0.2328	0.1786	0.2235	0.1736	0.0222
Mother Education					
Never Studied	0.1787	0.1468	0.1721	0.1425	0.0175
Primary Education	0.1618	0.1357	0.1542	0.1304	0.0210
Middle Education	0.2826	0.2028	0.2704	0.1973	0.0273
Secondary Education	0.1597	0.1342	0.1588	0.1336	0.0025
Tertiary Education	0.1537	0.1301	0.1774	0.1459	−0.0638

Source: Elaborated by the authors.

Note: Table 1 presents the overlap difference between the students in treated and untreated municipalities.

Additionally, a potential threat to identification refers to the geographical differences between exposed and not-exposed municipalities. Figure 2 illustrates the municipalities included in the analysis. We observe that municipalities highly exposed to long-lasting drought are geographically close to non-exposed municipalities. This minimizes the influence of

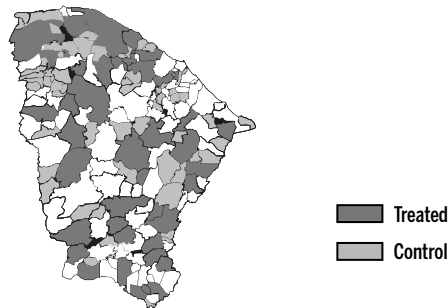
time-invariant, unobserved characteristics of schools and municipalities that potentially affect student socioemotional traits. Moreover, it indicates that students shared similar cultural conditions and economic markets. In the appendix, see Table A2, we check whether there is a difference between treated and untreated according to municipalities' characteristics. We find that the two groups are homogeneous when compared to a set of local indicators.

Third, and perhaps most relevant for the validation of our empirical strategy, cloud formation in the semi-arid makes precipitation during drought a quasi-exogenous event. The cloud (*cumulus nimbus*) that is typical of the semi-arid region is strongly affected by the winds that arrive from the coast. Therefore, the direction and resulting precipitation of these clouds are not correlated with a specific geographical region. Thus, two municipalities that share the same economic, agricultural, and cultural backgrounds can be highly affected or unaffected by drought. Figure 2 confirms this possibility, as nearby municipalities had different drought exposures over the period¹⁵. Considering only the treated municipalities, they had on average 55% of the months between 2012 and 2015 classified as moderately dry, this corresponds to approximately 26.4 months on average of drought. We compare the treated municipalities against the municipalities that did not record any months of drought between 2012 and 2015.

A potential source of confounding effects is the severe macroeconomic recession in Brazil between 2014 and 2016. This recession could have a differential impact on the treated and control municipalities, affecting the estimates since economic activity is related to socio-emotional and educational skills (Akee *et al.*, 2018; Barbosa, 2023). However, we expect that this shock has little effect on our estimates because the treated and control municipalities are geographically close, and possibly do not have different economic structures. In fact, the removal of the five largest municipalities from the sample contributes to the municipalities in the sample being quite homogeneous, as can be seen in Table A2, in the Appendix. In other words, considering that the municipalities have the same economic structure, it is not expected that they will have differential effects from the recessionary shock.

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15 The state of Ceará is quite flat, with little variation in height above the sea.

Figure 2 **Map of treated vs control municipalities**



Source: *Elaborated by the authors.*

Note: Figure 2 shows the geographic distribution of municipalities affected (Treated) and unaffected (Control) by drought during the period. We used the standardized precipitation index (SPI), calculated for each month between 2012 and 2015, to differentiate between the municipalities. A municipality was considered as treated if the proportion of months of drought exposure was above the 75th percentile. In turn, municipalities in the control group were not exposed to any drought months in the period.

4 Results

4.1 Main results

Table 2 presents the estimates of students highly exposed to the long-lasting drought shock on the five socioemotional traits in comparison with students not exposed to drought. We convert the socioemotional measures into standardized z-scores to facilitate the presentation of the results. In parentheses are the estimated standard errors, clustered at the municipal level. In brackets are the Romano-Wolf p-values, which provide multiple hypotheses testing correction¹⁶ (Romano and Wolf, 2005, 2016).

We observe that non-cognitive measures are negatively associated with exposure to large drought shocks. However, only Conscientiousness shows significant estimates. The correlation of living in a municipality exposed to

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16 The Romano-Wolf procedure uses re-sampling methods, such as the bootstrap, to asymptotically control the family-wise error rate (FWER), that is, the probability of rejecting at least one true null hypothesis in the family of hypotheses under test. It is more suitable for our case compared to other methods such as the False Discovery Rate (FDR) procedures because it accounts for any correlation between the outcomes, which is expected among socioemotional skills (Clarke *et al.*, 2020).

drought reduced nearly to 0.054s.d (p-value 0.003) the student's conscientiousness skill when compared to the student not exposed to the drought.

Table 2 Correlation of drought shock on socioemotional skills

Variables	(1) Agreeable- ness	(2) Conscien- tiousness	(3) Extrover- sion	(4) Emotional Stability	(5) Openness
Drought Shock	-0.002 (0.019)	-0.054 (0.026)	-0.013 (0.019)	-0.009 (0.017)	-0.004 (0.023)
Romano-Wolf p-value	[0.940]	[0.003]***	[0.691]	[0.797]	[0.940]
Observations	19,746	19,746	19,746	19,746	19,746
R-squared	0.029	0.024	0.025	0.067	0.033
Municipals controls	YES	YES	YES	YES	YES
Student Controls	YES	YES	YES	YES	YES

Source: Elaborated by the authors.

Note: Table 2 presents the estimates of the long-lasting drought period on the variables measuring the social-emotional skills of the Big Five Inventory. Standard errors were clustered at the municipal level. Romano-Wolf p-values are reported in brackets. Significance: *** 1%, ** 5%, and *10%.

The conscientiousness trait includes a range of skills that determine the propensity to be self-controlled, responsible towards others, hardworking, persistent, orderly, and virtuous. Our findings suggest that students' exposure to a long-lasting drought event reduces these skills during a critical period of adolescence. Several studies present evidence that conscientiousness skill predicts important long-term outcomes such as college entrance, graduation from high school, earnings, health status, and behaviors (Almlund *et al.*, 2011; OECD, 2017).

The drought shock only affected conscientiousness and a potential mechanism to explain this effect stems from the economic impact of the drought on students' aspirations. Dalton *et al.* (2016) state that economic shocks affect individuals' aspirations for future success. As a result, in anticipation of a lower expected probability of success in the future, individuals reduce their effort in the present. In turn, the reduction in effort in the present again impacts on aspirations for the future, resulting in a kind of behavioral trap. Effort is strongly associated with the trait of conscientiousness, defined as the ability to be determined, focused and persistent towards a specific goal. Other personality traits do not have a strong as-

sociation with individuals' aspirations; therefore, they are not expected to be impacted by the drought shock.

We examine whether long-term drought shock also affected some variables that measure student aspiration, such as expected schooling and the decision to continue studying after high school. To measure the student's aspirations, we explore a survey applied in conjunction with the SENNA Instrument. The survey asked about the expected education (the highest educational level the student intends to achieve), whether the students intend to drop out during high school, whether they expect to interrupt their studies after completing high school, and whether they expect to go to university.

The results are reported in Table A6. We obtained the estimates using similar specifications to Equation 2. The drought shock significantly reduced the expected education. Students exposed to the drought period reduce the expectation that they achieve elevated levels of education in their lifetime. There is an increase in the likelihood of students who indicate that they intend to stop studying right after high school and a reduction in the proportion of students who indicate that they intend to go on to university.

The correlation of drought shock on students' aspirations is in line with the findings on socioemotional skills. Drought reduces student conscientiousness, which is related to focus, persistence, and organization. The reduction of these factors may also contribute to the effects on students' aspirations for educational achievements.

Our findings suggest that the long-lasting drought shocks adversely affects factors related to effort in school, like persistence, focus, and determination. Shah and Steinberg (2017) found that a short-run negative rainfall shock raises the opportunity cost of students to leave the school. Droughts may impact the local labor markets, particularly in agricultural areas, decreasing the expected returns to child labor. That represents an incentive to stay at school and to learn. As a consequence, the short-run unfavorable rainfall shocks increase the student's test scores. We found contrary evidence when considering long-lasting drought shocks. Even if the drought increased school enrollment and students' progression, simultaneously, it led to a decrease in socioemotional skills among the youth. Our results are analogous to Nordstrom and Cotton (2020) which find that severe short-run droughts negatively impact student non-cognitive skills.

Long periods of droughts may represent a relevant income shock to families in agricultural areas, increasing the cost of staying at school. Akee *et al.* (2018) find that a positive shock on household income has a beneficial effect on children's personality traits. The mechanisms for this effect include improved relationships between parents and their children, as well as between the parents themselves, along with enhanced mental health and reduced stress levels among parents, all resulting from increased household income. Thus, variations in household income can be a potential channel to explain the relationship between drought shocks and personality.

4.2 Robustness

We check the robustness of these results in different ways. The main limitation of our empirical strategy is the possibility of students' families' adaptation to the drought period. One of the main ways to adapt to climate change is migration. For instance, students' families could migrate to municipalities that were not very exposed to droughts, confounding the results. Using administrative student identification provided by the Secretariat of Education of the State of Ceará (SEDUC), we identify students who migrate during the drought period. We then regress the binary variable indicating whether students migrated during the drought period against the treatment. Our goal is to identify whether student migration is correlated with drought exposure.

We consider a student as a migrant if he/she enrolled in a school in a different municipality between 2012 to 2015, the period of the drought occurrence. We present the results in the Table A5, in the Appendix. The results suggest that student migration is not correlated with the exposure of municipalities to drought. This result is in line with the evidence that, although this drought event has been unprecedented over the past eighty years, there have been several policies that have contributed to mitigating its most severe effects, such as crop insurance, conditional cash transfer programs, and intergovernmental emergency transfer to municipalities most affected by drought (De Oliveira, 2019; De Oliveira *et al.*, 2020). Thus, even if a county has been exposed to drought, such amenities reduce the odds of the student's families choosing to migrate.

In addition, we provide several sensitivity tests to check the robustness of the main findings. First, we consider two alternative measures of drought shock. In our main specification, we define a municipality as being exposed to drought using a binary variable according to the proportion of dry months measured by the SPI. Specifically, municipalities considered to be exposed to drought shock were those above the 75th percentile of dry period months.

We consider as alternative measures the total number of months that a municipality is exposed to a dry period according to the SPI (Alternative Measure I) and the median months of dry periods (Alternative Measure II). The estimates are presented in Table A3. In both cases, the impact of a drought shock is negative on the conscientiousness trait, similar to the main results. The effect of the continuous drought shock has risen to -0.66 s.d (p-value 0.222) and the effect of municipalities above the median is -0.35 s.d (p-value 0.046). However, despite the similar effect size, the variance also increased, and only Alternative Measure II presented statistical significance. A possible explanation for the increased uncertainty of the estimates is related to the dynamic occurrence of drought from 2012 to 2015. The municipalities may have been equally affected but in different periods between 2012 and 2015, generating noise in the sample. We tried to mitigate this potential noise by considering as treated only the municipalities that had many dry months (above the 75th percentile).

We also tested the inclusion of nonlinearities in the controls. In particular, we included in the main regression the square of the control variables. The estimates reported in Table A3 are not different from the main results, suggesting that the estimates are stable to the introduction of additional control variables.

Finally, our data present missing control variables. Thus, we impute missing controls by assigning the overall sample mean to each observation with missing information for a continuous control variable and a new missing category to each observation with missing information for an indicator variable. We also included indicator variables to determine whether a variable is imputed. We re-estimated Equation 2 using imputed controls. The results, presented in Table A4, are similar to the main results. Only the conscientiousness skill is negatively affected by the drought shock.

Taken together, our estimates suggest that long-lasting drought shock adversely affects the conscientiousness trait, and this finding is robust to several specification checks.

4.3 Estimation on the facets of personality traits

To understand the results in greater detail, we estimate the same empirical strategy on the facets of the effect of conscientiousness traits. A special feature of the SENNA instrument is the possibility to decompose the Big Five personality traits according to their facets. The facets represent a narrowly defined factor related to a broadly defined trait (*e.g.*, Conscientiousness). The main advantage of analyzing the facets is the possibility of providing a more precise description of student behavior (Soto and John, 2017). Each broad Big Five domain of the SENNA instrument can be conceptualized as containing several specific facet traits, and the SENNA instrument allows simultaneous access to personality at both the domain and facet levels. A growing body of research has adopted this approach to measure personality traits (Costa Jr and McCrae, 1995; Soto and John, 2017; OECD, 2017). We obtain the facets constructs using the principal component estimator applied to the set of questions associated with each facet. We report the results in Table 3.

We observe from Table 3 that some facets related to Conscientiousness are significantly affected by the shock of the long-term drought. The Organization, Focus, and Persistence facets are negatively and significantly impacted. Determination is also negatively impacted, but not significantly. When we estimate *p*-value correcting for multiple testing, Determination is significant at 5%. The estimated size, however, is similar to the other Conscientiousness facets. The largest estimated effects are on Focus, Organization (-0.046 s.d), and Persistence (-0.050 s.d), suggesting that students in highly drought-exposed municipalities have difficulty focusing their attention on educational activities, organizing their activities, and persisting in achieving their goals. All estimations presented statistical significance at 1%, except Determination, which was less impacted and statistically significant at 5%.

Some recent evidence points out the impact of poverty on individual cognitive function, like attention (Mani *et al.*, 2013; Shah *et al.*, 2018). For instance, factors related to drought episodes, like malnutrition or money concerns, may affect the mental capacity of the student to concentrate on specific activities. The organization is related to the capacity of planning activities to reach a goal and to manage appointments in the future. Like the focus and persistence facets, the drought shock affects the student's

mental capacity to plan. And lastly, the drought shock also significantly affects persistence skills, defined as the ability to overcome obstacles to complete tasks, rather than procrastinating or giving up when situations get difficult or uncomfortable.

Table 3 The correlation of long-lasting drought shock on Conscientiousness' facets

Conscientiousness' facets	Determination	Organization	Focus	Persistence
Drought Shock	-0.028 (0.025)	-0.046*** (0.023)	-0.046*** (0.025)	-0.05 (0.025)
Romano-Wolf p-value	[0.019]	[0.003]	[0.003]	[0.003]
Observations	18,103	18,392	18,188	17,933
Municipal Controls	YES	YES	YES	YES
Student Controls	YES	YES	YES	YES

Source: Elaborated by the authors.

Note: Table 3 presents the estimates of the long-lasting drought period on the variables measuring the facets of the Conscientiousness' skills. Standard errors were clustered at the municipal level. Romano-Wolf p-values are reported in brackets. Significance: *** 1%, ** 5%, and *10%.

4.4 Heterogenous Analysis

Drought shock events may have varying effects on different groups of students. To explore this possibility, we conducted an analysis focusing on heterogeneous analysis. We examined two student characteristics that could potentially influence the impact of extreme low precipitation shocks. The first characteristic is student gender. Previous research suggests that girls may be more vulnerable to economic and natural shocks (Neumayer and Plümper, 2007; Enarson *et al.*, 2018). The second characteristic relates to educational background. We aimed to determine whether students who have previously repeated a school year might experience a stronger impact from drought shocks. Student quality could potentially mitigate the effect of low precipitation shocks on socioemotional skills.

We measured the heterogeneous analysis by interacting a student characteristic variable, that we call as factor, with the *Treat* variable representing treated students. We included both variables, the factor and the interaction, in the empirical strategy adopted in Equation (2). We consider two

students characteristics: female gender status and whether the student had repeated any previous grades. The empirical specification is as follows:

$$y_{ims} = \alpha_0 + \alpha_1 Treat_m + \alpha_2 factor_{ims} + \alpha_3 factor_{ims} \times Treat_m + \theta'_1 X_{ism} + \theta'_2 X_m + \varepsilon_{ims} \quad (4)$$

where: $factor_{ims}$ can be gender female status (girls) or students who have repeated a grade. The results are presented in Table 4.

Table 4 Heterogenous Analysis

Variables	(1) Agreeable- ness	(2) Conscien- tiousness	(3) Extrover- sion	(4) Emotional Stability	(5) Openness
Female gender status					
Treat	0.021 (0.025)	-0.047 (0.034)	-0.008 (0.026)	0.007 (0.023)	0.012 (0.031)
Treat x Girls	-0.025 (0.031)	-0.008 (0.034)	0.010 (0.031)	-0.014 (0.029)	-0.024 (0.030)
Girls	0.226*** (0.019)	0.131*** (0.019)	-0.082*** (0.017)	-0.510*** (0.019)	-0.114*** (0.018)
Repeating students					
Treat	0.016 (0.022)	-0.040 (0.030)	0.000 (0.022)	-0.007 (0.021)	0.006 (0.027)
Treat x Repeated	-0.040 (0.024)	-0.051 (0.033)	-0.013 (0.027)	0.031 (0.033)	-0.036 (0.029)
Repeated	-0.212*** (0.023)	-0.275*** (0.025)	-0.165*** (0.022)	-0.173*** (0.023)	-0.180*** (0.026)
Municipal Controls	YES	YES	YES	YES	YES
Student Controls	YES	YES	YES	YES	YES

Source: Elaborated by the authors.

Note: Table 4 presents the estimates of the prolonged dry period in the variables that measure the socio-emotional skills of the Big Five Inventory considering the student's gender and whether the student had repeated a previous grade. Standard errors were clustered at the municipal level. Significance: *** 1%, ** 5% and *10%.

We do not find evidence of the presence of heterogeneity in girls or students with lower prior education. Beside the negative impact estimation for all socioemotional skills, the estimates are non-significative. The results suggest that boys and girls are equally affected by the drought shock

on their socioemotional abilities, and that prior education does not mitigate the effect of low precipitation shocks.

5 Final Remarks

This paper documents that a prolonged drought shock affects the socioemotional skills of adolescents. We investigated the correlation of a four-year drought on the socioemotional skills of students in the state of Ceará, Brazil. The personality trait of conscientiousness was significantly and adversely affected by the drought. The conscientiousness trait is strongly related to long-term individual outcomes such as salary, enrollment in college, and increased life expectancy (Almlund *et al.*, 2011; Heckman *et al.*, 2019).

Additionally, we analyze the impact of drought on facets associated with these personality traits. The facets measure aspects more closely related to student behavior. The results showed that the facets of organization, persistence, and focus were also negatively affected by the drought shock. Finally, we found that the correlation of the drought on conscientiousness skills is related to a reduction in students' aspirations for the future to continue their education.

Our findings provide important insights for public policy-making, especially in areas most vulnerable to drought. While many actions have been developed to reduce the economic damage of drought events, it is necessary to focus on policies that also mitigate the effects of drought on students' socio-emotional skills.

This paper showed that a steep increase in drought can affect students' socioemotional skills, especially at sensitive ages of socioemotional formation. Contrary to existing empirical findings on the impact of precipitation shocks, we provide evidence that the impact of drought can affect other characteristics that make up human capital beyond cognitive skills. Previous literature may underestimate the cost of a drought shock. If climate change intensifies the occurrence of droughts, specific public policies should be designed to address students' socioemotional skills, given their importance to students' well-being.

Two limitations are associated with this paper's conclusions. First, given that our outcome variable is cross-sectional, dynamic effects of temporal

variability may affect the estimates. Additionally, spatial regression models may fit the data better by attempting to control for potential spatial autocorrelation bias. We expect to address these limitations in future studies.

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Contribution of the authors

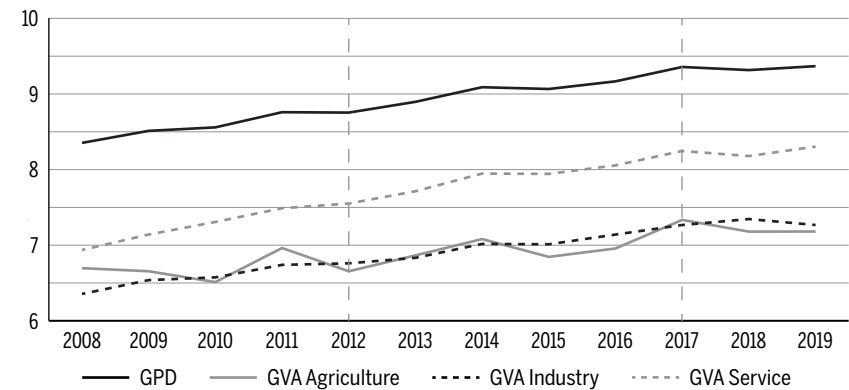
Both authors worked together on the text, data processing and empirical estimations.

About the article

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APPENDIX

Figure A1 Temporal evolution (2008-2019) of GDP and Gross Values Added (GVA)



Note: Figure A1 presents the temporal evolution (2008-2019) of the average GDP and the average gross value added (GVA) of the agriculture, industry, and services/trade sectors in the municipalities of Ceará. All values have been adjusted on a per capita basis, deflated using the implicit log GDP deflator based on 2019. The dotted lines denote the drought period in the region, according to the Brazilian Ministry of Integration.

Table A1 Balance checks between students that answered and not answered correctly the SENNA questionnaire

Variables	Answered correctly		Do not answered correctly		Balance Std-diff
	Mean	Variance	Mean	Variance	
Racial Status					
White	0.201886	0.161133	0.203974	0.162377	−0.0051
Brown	0.587751	0.242307	0.081927	0.075219	0.0846
Black	0.059734	0.056167	0.545836	0.247913	−0.0865
Demographic Factors					
Age	9.689.527	148.789	9.791.453	3.556.321	−0.0642
Girls	0.581679	0.243336	0.433043	0.24553	0.3006
Residents in household	3.863.919	3.076.725	3.962.167	3.565.502	−0.0539
Prior Education					
Preschool	0.8322	0.139645	0.808873	0.154606	0.0608
Kindergarten	17.734	0.457373	1.790.201	0.499507	−0.0243
Repeated	0.232924	0.178676	0.365814	0.232007	−0.2933

Note: Table A1 presents the difference in overlap between students that answered and not answered correctly the SENNA questionnaire.

Table A2 Balance checks between treated and untreated municipalities

Variables	Low Exposure		High Exposure		Difference
	Obs	Average	Obs	Average	
Proportion of 1/4 minimum wage	49	41.614	61	41.971	-0.357
Ratio +10/40-	49	28.08	61	27.005	1.076
Per capita income	49	253.18	61	251.99	1.193
Inequality Gini Index	49	0.538	61	0.534	0.004
Proportion of illiteracy	49	26.371	61	27.025	-0.653
Distance from capital	49	235.47	61	204.45	31.018
Proportion of poor (Head count ratio)	49	24.419	61	24.166	0.253
HDI municipal	49	0.616	61	0.61	0.005
Proportion of elderly	49	12.105	61	12.108	-0.003

Source: Elaborated by the authors.

Note: Table A2 presents the balance difference between treated and untreated municipalities socio-economic factors. The last column (Difference) performs the t-test of equal mean. Significance: *** 1%, ** 5%, and *10%.

Table A3 Robustness check

Variables	(1) Agreeable- ness	(2) Conscien- tiousness	(3) Extrover- sion	(4) Emotional Stability	(5) Openness
Alternative Measure I	0.035 (0.059) [0.946]	-0.066 (0.079) [0.222]	0.007 (0.056) [0.930]	0.000 (0.056) [0.930]	0.017 (0.070) [0.946]
Alternative Measure II	0.008 (0.017) [0.900]	-0.035 (0.025) [0.046]**	0.002 (0.016) [0.810]	-0.002 (0.015) [0.730]	0.011 (0.020) [0.810]
Additional controls	-0.005 (0.019) [0.717]	-0.06 (0.025) [0.003]***	-0.019 (0.019) [0.322]	-0.014 (0.019) [0.584]	-0.010 (0.022) [0.661]
Municipal Controls	YES	YES	YES	YES	YES
Student Controls	YES	YES	YES	YES	YES

Source: Elaborated by the authors.

Note: Table A3 presents the robustness exercises for the estimates of the main outcome. Three robustness exercises are performed. The first two exercises consider alternative measures of drought shock, while in the third, we include additional controls for nonlinearities. Standard errors were clustered at the municipal level. Romano-Wolf p-values are reported in brackets. Significance: *** 1%, ** 5%, and *10%.

Table A4 Association of drought shock on socioemotional skills – Imputed controls

Variables	(1) Agreeable- ness	(2) Conscien- tiousness	(3) Extrover- sion	(4) Emotional Stability	(5) Openness
Drought Shock	-0.004 (0.018)	-0.058 (0.024)	-0.021 (0.018)	-0.009 (0.016)	-0.012 (0.022)
Romano-Wolf p-value	[0.717]	[0.001]***	[0.170]	[0.661]	[0.661]
Observations	23,355	23,355	23,355	23,355	23,355
R-squared	0.036	0.032	0.025	0.062	0.032
Municipal Controls	YES	YES	YES	YES	YES
Student Controls	YES	YES	YES	YES	YES

Source: Elaborated by the authors.

Note: Table A4 presents the estimates of the long-lasting drought period on the variables measuring the social- emotional skills of the Big Five Inventory. The controls included imputed observations on missing values in independent variables. Standard errors were clustered at the municipal level. Romano-Wolf p-values are reported in brackets. Significance: *** 1%, ** 5%, and *10%.

Table A5 Correlation of municipality drought shock on student migration

Variables	(1)	(2)	(3)
Drought Shock	0.0075 (0.023)	0.0104 (0.023)	0.0183 (0.019)
Observations	32,413	30,2	32,413
R-squared	0.028	0.022	0.025
Municipals controls	NO	NO	YES
Student Controls	NO	YES	YES

Source: Elaborated by the authors.

Note: Table A5 presents the estimates of municipal drought exposure on the probability of a student migrate during the drought period. Standard errors were clustered at the municipal level. Significance: *** 1%, ** 5%, and *10%.

Table A6 Association of drought shock on student aspirations

Variables	(1) Expected Education	(2) Stop after High School	(3) Go to university
Drought Shock	-0.048 (0.017)	0.012 (0.008)	-0.028 (0.010)
Romano-Wolf p-value	[0.003]***	[0.019]**	[0.003]***
Observations	19,559	19,746	19,746
R-squared	0.092	0.022	0.080
Municipal Controls	YES	YES	YES
Student Controls	YES	YES	YES

Source: Elaborated by the authors.

Note: Table A6 presents the results of the drought exhibit on students' educational expectations. We estimate a similar specification to Equation 2. Romano-Wolf p-values are reported in brackets. Significance level: *** 1%, ** 5%, and *10%.

Table A7 Correlation of drought shock on socioemotional skills – All municipalities

Variables	(1) Agreeable- ness	(2) Conscien- tiousness	(3) Extrover- sion	(4) Emotional Stability	(5) Openness
Drought Shock	0.010 (0.021)	-0.044* (0.025)	-0.018 (0.019)	-0.013 (0.018)	-0.006 (0.023)
Observations	45098	45098	45098	45098	45098
R-squared	0.027	0.024	0.022	0.069	0.031
Municipals controls	YES	YES	YES	YES	YES
Student Controls	YES	YES	YES	YES	YES

Source: Elaborated by the authors.

Note: Table A7 presents the robustness exercises for the estimates of the main outcome considering students in all municipalities. Standard errors were clustered at the municipal level. Significance: *** 1%, ** 5%, and *10%.