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El Niño and Firms: Impact on Food and Beverages Manufacturing Firms in Ethiopia

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Abstract

This paper examines the effect of the extreme drought, which is caused by El Niño on firms' performance in food and beverage manufacturing sector in Ethiopia. Combining panel data of Ethiopia Manufacturing Firms, remote sensed data on rainfall from CHIRPS database, and survey, we build a district - level measure of El Niño exposure and use within district variation over time to employe difference-in-difference estimation. We find that El Niño exposure decrease firms' performance in terms of sales, employment, total factor, and labor productivity. The finding was robust to different model specifications. We identify shortage of domestic-sourced raw materials as a main channel: El Niño drought shock reduces the availability of domestic raw material.

Keywords: Drought, El Niño, Employment, Ethiopia, Productivity, and Sales

JEL classifications: D21; D22; Q54

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1 Introduction

Droughts have intensified and become more frequent in recent years due to climate change (Tollefson, 2021, 2022), with developing countries, having lower adaptive capacities, experiencing a heightened impact. While much of the climate change literature focuses on predicting future impacts, understanding the current impacts is also important (Carleton & Hsiang, 2016). Moreover, the existing literature on the impacts of extreme droughts has largely focus on health and welfare effects in general and farm households in particular (e.g., Cooper et al. (2019); Orimoloye (2022)). However, evidence on the impact of droughts on firms and manufacturing sector is scarce (see e.g., (Lin & Sheng, 2022)). There is no empirical study on how the El Niño drought affects manufacturing firms, particularly food and beverage manufacturing firms. Given the projected doubling of the frequency of extreme El Niño events in the future (Cai et al., 2014), there is a need for evidence on the effect of these events on manufacturing firms to support effort for enhancing the adaptive capacity and resilience of firms.

This paper examines the impacts of the El Niño induced drought on manufacturing firms' performance in Ethiopia. El Niño is an extreme atmospheric condition that periodically warms the water across the central and east-central Equatorial Pacific. In this study, we specifically focus on the 2015-16 El Niño event, which triggered one of the worst droughts in the central and northern parts of Ethiopia in decades. Specifically, we aim to answer three research questions: First, does El Niño drought affect food and beverage manufacturing firms' performance, as measured in terms of firm's sale, employment, and total factor and labor productivity? Second, what are the mechanisms through which extreme drought affects firm's performance? Third, what strategies do surviving firms adopt to cope and adapt to droughts?

To identify the causal impact of El Niño drought on food and beverage manufacturing firms, we use a difference-in-differences approach by exploiting the time and spatial variation of the 2015 El Niño drought. The treatment group comprises firms located in El Niño induced drought-affected districts, while the control group consists of firms operating in non-affected districts, we assign the 2015 to 2016 period as a treatment period and the 2012-2014 period as a pre-treatment period.

Our analysis draws upon data from three sources. First, we use the annual Ethiopia Large and Medium Manufacturing Firms census collected by the Central Statistical Agency (CSA) of Ethiopia.[1] The census provides he establishment's location at district level, the second lowest administrative unit of Ethiopia, which help us to exploit the geographic variations and create a treatment variable for identification at a district level. Second, we use Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data, a gridded spatial dataset of about 0.05-degree resolution (approx. 5550 meters). We calculate the Standardized Precipitation Index (SPI) from this data, which measures precipitation deviation of precipitation from its long-term trend (30 years). Districts with an average SPI less than -2 are considered as drought affected and all other districts are considered as non-drought affected. Third, to identify the coping and adaptation strategies that firms use to

[1] In Ethiopia, large and medium manufacturing firms under the CSA are characterized as enterprises utilizing power-driven machinery and employing a workforce exceeding ten employees.

deal with droughts, we administer a survey of random sample of surviving firms in drought affected districts. The survey asks firms' managers about the coping and adaptation strategies they used to continue operating during the droughts.

Our results show that El Niño induced drought has a negative impact on the performance of food and beverage manufacturing firms in Ethiopia. Specifically, firms in El Niño exposed districts experience decrease in sales, employment, total factor productivity (TFP) and labor productivity compared to firms in districts that were not exposed to El Niño drought. The results are robust to different specifications, including the inclusion of control variables and several fixed effects. Our mechanism analyses provide suggestive evidence that the observed effect is due to two mechanisms: (1) El Niño shock results reduction in the availability of domestic inputs (raw materials), which leads to a reduced production, revenues, employment, and TFP and (2) firms fail to substitute the reduction in domestic inputs use with imported inputs. To mitigate the effects of the drought, most firms reduced their production capacity as a primary coping strategy followed by buying inputs from areas that are not affected by the drought and increasing the price of their produce.

Our work contributes to the literature on the impact of climate change and climate change induced extreme events on firms' performance. Cheng and Yang (2019) and Zhang et al. (2018) assess the effect of climate change - in terms of change in temperature - on firm output in China. The studies reported that temperature reduces firm's output. This overall effect varies across (i) seasons - higher temperature during summer seasons reduce output while higher spring temperature increases, and (ii) regions - higher summer temperature has higher reduction in output in low-temperature areas than high-temperature areas (Chen & Yang, 2019). The reduction in output is due to loss of productivity (total factor productivity), not through factor inputs - capital and labor (Zhang et al., 2018). Somanathan et al. (2021) find the negative effect of temperature on firm output in India. The effect is mainly due to reduced labor productivity and higher labor absenteeism. Acevedo et al. (2020) undertake a global analysis to explore the macro-economic impact of high temperature and find out that high temperature depresses per capita output through affecting investment, labor productivity, human health, and agricultural and industrial output. The observed effect is the largest in low-income countries.

The paper also contributes to the broad literature on the impact of climate change and extreme climate change events on a variety of outcomes, beyond firm performance. Most of this literature focuses on the impact of climate change in developing on crop production and agricultural households and communities (see e.g., Ahmed et al. (2009); Benhin (2008); Connolly-Boutin & Smit (2016)). Other studies examine the effect on migration (see e.g., Carleton & Hsiang (2016)), conflicts (see e.g., Carleton & Hsiang (2016)), health (see e.g.,Andalón et al. (2016); Aguilar & Vicarelli (2022)), macro-economic outcomes - e.g., growth and inflation (see e.g., Cashin et al. (2017)). Dell et al. (2014) review the literature on the impact of temperature, precipitation, and windstorm on economic outcomes. Most of the studies have documented a negative effect of climate change and climate change disasters.

Most of the existing studies have primarily focused on the impact on temperature, but not on specific drought events. As droughts are different from a change in temperature, the effect of drought events on firms could be different from temperature and precipitation changes. Studies on the coping and adaptation strategies of firms are scant to climate change, climate change-induced extreme events, including droughts. Hence, this study contributes to the two strands of literature by exploring the impact of El Niño drought on firms' performance and identifying the coping and adaptation strategies employed by surviving firms. By properly quantifying the effect of and exploring the coping and adaptation strategies to such extreme weather events, the finding of our study helps policy makers to make an informed decision to mitigate drought impact on firms. The study also advances our understanding of the impact of extreme weather events on the firm dynamics in terms of employment creation, firm entry, survival, and growth.

2 Climate Change and El Niño in Ethiopia

Like many other countries, Ethiopia has witnessed climate change and extreme climatic events in recent decades, including increasing temperature, erratic rainfall, droughts, and floods (Teshome & Zhang, 2019; Mamo et al., 2019). In fact, Ethiopia stands as the most susceptible to the adverse impacts of climate change (Cochrane & Singh, 2017; Gashaw et al., 2014). About 70% of the country is characterized by drylands, where there is a 40% annual probability of moderate to severe drought, particularly in the smallholder farming systems (Singh et al., 2016), where rainfed agriculture is the most common livelihood strategy (Bezu et al., 2012; Gebrehiwot & Van Der Veen, 2015). Studies has shown that the changing climate and the high degree of vulnerability has led to the reduction in production and fall income (see e.g. Deressa & Hassan (2009)). Predictions show that a substantial rise in mean temperature and rainfall variability, increasing the intensity and frequency of both droughts and floods. For instance, Deressa & Hassan (2009), Gebreegziabher et al. (2016) and Solomon et al. (2021) reported that change in temperature and precipitation will lead to significant reduction in agricultural productivity and income in the future.

El Niño, a climate pattern of unusual warming of the surface waters in the eastern Pacific Ocean, has been responsible for Ethiopia's worst droughts and the increase in the intensity and frequency of droughts in Ethiopia in recent years. El Niño distorts the hydroclimatological process and the distribution and intensity of rain. In most part of Ethiopia, El Niño causes significant reduction in summer (kiremit) rainfall (Gleixner et al., 2017; Haile et al., 2021). While Ethiopia has previously experienced El Niño induced droughts, these occurrences have become more frequent and intense in recent years. The country experienced its worst drought in half a century during in 2015-16, when rain failed in spring (belg) followed by El Niño induced weaker summer rains (FEWS, 2015). This drought has significantly reduced agricultural production (Haile et al., 2021), increased food insecurity, malnutrition, ruined livelihoods of peoples and communities in six (of the nine) regions of the country and left about 10.2 million people in need of urgent food assistance (OCHA, 2015; FEWS, 2015).

There is empirical evidence on the impact of the drought in Ethiopia on several socio-economic outcomes. For instance, Kasie et al. (2020) assess the impact on household consumption and find that drought had a negative impact on household consumption, and that this impact was larger for poorer households.Hirvonen et al. (2020) examine the impact on child health outcomes, measured in undernutrition and found no overall effect of the drought, albeit the drought increased acute malnutrition rates in drought-affected areas with poor road infrastructure. In contrast, Dimitrova (2021) assessed the impact of droughts in Ethiopia and found that drought exposure during the main agricultural season increased both stunting (chronic undernutrition) and wasting (acute undernutrition) among children under the age of five: the effect was larger for boys, children with uneducated mother, in rural areas, and in agricultural households. Eze et al. (2022) assessed the relationship between 2015-16 drought and crop loss in Southern Tigray, Ethiopia and documented a significant crop loss induced by the drought. Most of the studies in the literature in Ethiopia has focused on the impact of the drought on agriculture or agricultural households, consequently evidence on the impact of the drought firms, particularly manufacturing firms are scant. This limits our understanding of the actual impact of severe droughts on firms in Ethiopia to design evidence-based interventions to enhance the adaptive capacity of firms and come up with effective adaptation strategies to minimize the consequence of upcoming droughts in Ethiopia.

3 Data

We used three datasets: Data on Ethiopia's large and medium manufacturing firms, Climate Hazards Group InfraRed Precipitation (CHIRPS), and survey of firm's perception on the impact of the 2015 El Niño drought, coping and adaptation strategies.

3.1 Ethiopia's large and medium manufacturing data

We use the annual census of Ethiopia's large and medium manufacturing firms from 2012 to 2018. This census is collected by the Central Statistics Authority (CSA) of Ethiopia. The survey covers all manufacturing firms that employ at least 10 people and use power-driven machines. The most detailed industry classification level is at four digit. The census provides detailed information about the firms: sales (revenue), total capital stock, total employment – disaggregated by gender, occupation (both production and administrative), the value and quantity of output, type of ownership and manufacturing, location (at district level and above), and value of exports and imports. We estimate the firm's total factor productivity (TFP) using the Levinsohn Petrin (LP) method. Table 1 presents the summary statistics for the key variables for the food and beverage manufacturing establishments for 2012 and 2018. Table 1 shows a meaningful variation across establishments in the variables of interest.

Table 1: summary statistics for the key variables in the census data

	Number	Mean	SD	Max	Min
Log(Local raw materials)	2469	15.02	2.35	21.06	0
Log(Imported raw materials)	1382	13.83	3.75	21.42	0
Log(Total raw materials)	2589	15.48	2.31	21.51	0.69
Log(Wage)	2513	12.68	1.87	20.68	6.91
Log(Sales)	2551	15.9	2.16	22.58	8.1
Log(Fixed asset at the beginning)	2479	14.02	2.95	21.98	0
Log(Fixed asset at the end)	2536	14.07	2.81	22.27	0
Log(Employment)	2551	3.33	1.38	9.12	0

Notes: The monetary variables expressed in nominal terms are converted to constant prices (2016) using GDP deflator from the World Development Indicators (WDI). The variables are in log values and zeroes are dropped..

As firms' GPS location is not available at firm level, we construct a pseudo panel using district as a unit of analysis by taking the average values of the variables of interest for all firms located in the district.

3.2 Climate Data

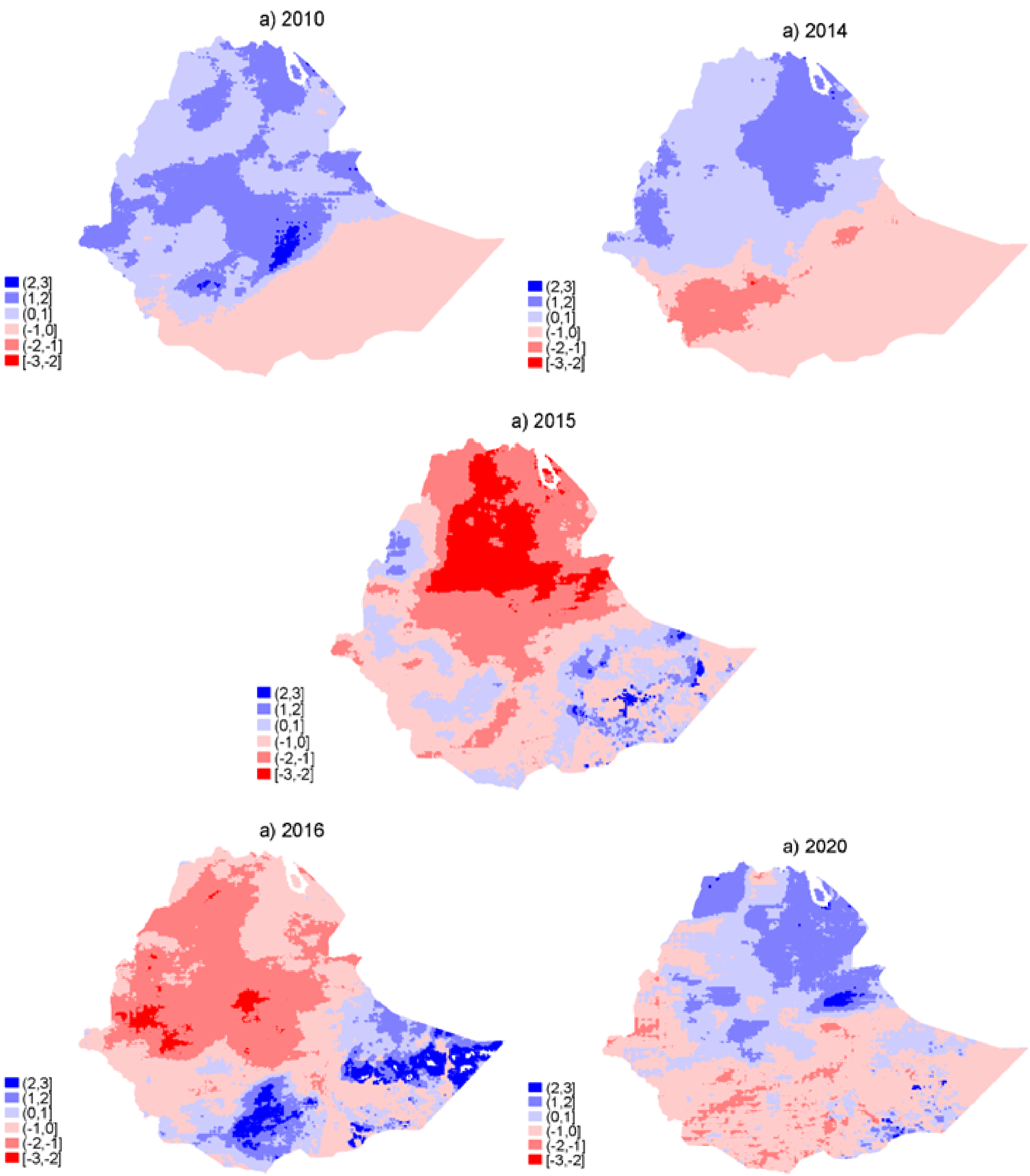
We measured El Niño induced drought using the Standardized Precipitation Index (SPI) for 2015/2016, the year that El Niño event occurred. SPI measures the deviation from the long-term mean precipitation (for 30 years in the current paper) for a monthly time scale, providing information about dry (drought) and wet (flood) conditions. In other words, it is a standard deviation that the observed precipitation would deviate from the long-term mean; we used about 30 years. The SPI was calculated using a monthly Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data, a gridded dataset of about 0.05-degree resolution (approx. 5550 meters). We calculated SPI for the summer - the main cropping season in Ethiopia, covering the months of June, July, and August - for each pixel for the years from 2010 to 2020 (see Figure 1 for the distribution of the SPI values for the years 2010, 2014, 2015, 2016, and 2020). The maps clearly show that the year 2015 was indeed drier than the preceding and succeeding years and parts of areas located in northern, north central, and eastern Ethiopia experienced drier conditions, confirming reports on the distribution of dry conditions in Ethiopia during that decade.

As our firm-level data is aggregated at district-level due to lack of access of the geo-location of the firms, we also aggregate - using the average of - the pixel level SPI values at district level. Based on the aggregated values, we defined our main binary treatment variables that takes a value one for districts with an average SPI value of less than -2 (drought affected) and zero otherwise.

3.3 Survey Data

We have conducted a survey of 100 survived firms in Food and Beverage sector from a recent database of the Central Statistics Authority of Ethiopia (CSA) for two purposes. First, to shed light on how firms survive to extreme weather events (El Niño drought). Second, to learn about the unobservable channels though which El Niño affect firm's business. Given the retrospective nature of our investigation, we target - as a respondent - founders or managers who were employed during

Figure 1: Distribution of rainfall Z-score (SPI) in Ethiopia by year



Notes: places with SPI of less than -2 are considered drought affects areas.

the 2015/16 El Niño period. Our survey instrument has four main components. The first component asks basic information about the establishment. The second component asks the mechanism through which El-Nino drought affect their business activities. The third component inquires how firms survive to extreme weather events- the 2015-16 El Niño drought. The fourth component asks firms view about the appropriate government responses to mitigate the negative impacts of the climate shoch like El-Nino drought on their operations.

4 Empirical strategy

To identify the impact of El Niño drought on performance of food and beverages manufacturing firms, we exploit the time and spatial variations in drought caused by El Niño using the following basic difference-in-difference model:

$$Y_{idt} = \alpha ElNio_{idt} + \gamma Time_{idt} + \beta Treatment_{idt} + \tau Z_{idt} + \delta_y + \delta_d + \epsilon_{idt} \qquad (1)$$

where Y_{idt} denotes firm i's performance indicators including sales, productivity, and growth at district (woreda) d in year t. $ElNio_{idt}$ stands for firm's treatment status based on spatial location, taking a value one for firms located in districts affected by the El Niño drought in 2015-16 and zero otherwise. $Time_{idt}$ stands for firm's treatment status temporally, taking a value one for the 2015 to 2018 period and zero for the 2012 to 2014 period. $Treatment_{idt}$ is the treatment effect, which is the interaction between $ElNio_idt$ and $Time_{idt}$. It is a binary variable indicating whether firm i operates in El Niño drought affected district (woreda) d at drought affected time t. The coefficient,β, is our parmeter of interest; it is the treatment effect and can be interpreted as the average effect of El Niño induced drought on firm outcomes given there are no missing variables that cause the outcome variable of interest to change differently with change in treatment status (drought incidence) as time changes. In our estimation, we cluster standard errors by district-year to account similarity of observation within district and year.

In the specification, we also control year fixed effect (δ_y), district fixed effect (δ_d) and a vector of firm control variables (Z_{idt}). The district fixed-effect controls for district-specific unobservables, e.g., the quality of institution, and policy shocks within the geographical district, that may correlate with establishment-level outcomes and El-Nino drought exposure. The year fixed effect controls for year-specific unobservables that may correlate with establishment-level outcomes and El-Nino drought exposure. The firm control variables account differential effect of the drought on that our dependent variables across firms due to differences in firm characteristics. The control variables include firm age, size, export and import status.

We also examine the mechanisms that may explain the impact of El Niño drought on performance of food and beverages manufacturing firms. Extreme drought may constrain food and beverage manufacturing firms' performance by reducing their access to domestic production raw materials. Existing evidence shows that the 2015-16 El Niño drought caused widespread crop failure, death of livestock, and loss of livestock production (FAO, 2016; UNICEF, 2016; Philip et al, 2018).

This could lead to shortage of raw materials that in turn affect SME's production performance. We use the following basic model for the mechanism analysis:

$$M_{idt} = \alpha ElNio_{idt} + \gamma Time_{idt} + \beta Treatment_{idt} + \tau Z_{idt} + \delta_y + \delta_d + \epsilon_{idt} \qquad (2)$$

M_{idt} stands for the value of raw materials used by firm i at district (woreda) d in year t. We consider three types of raw materials: domestic, imported, and total. All the notations, extension and estimation approaches are as explained in equation 1.

Our difference-in-difference impact estimates rest on the parallel trend assumption, which states without the incidence of El Niño induced drought, the treatment and control firms would follow a similar trend in outcome. To check the validity of this assumption, we present a series of figures that show the pattern – between 2012 and 2016 – of average firms' input use and performance: firm's (i) sales and production (Appendix A), (ii) productivity (total factor and labor) (Appendix B), (iii) employment (Appendix C), and (iv) use of raw materials (Appendix D). In the figures, the blue and red lines represent the trends for the control and treatment districts, respectively while the vertical (dotted) red line represents the treatment year. All the figures show a similar trend for both treatment and control districts during the pre-drought period, which is an indication that parallel trend assumption holds for the validity of difference-in-difference estimation for all input use and performance variables.

5 Results and discussion

5.1 Output

In this section, we present results from estimating equation (1). The first outcome variable we consider are output (proxied by sales). Table 2 presents the estimates of the effect of El Niño exposure on firms' sales. In column 1, we do not include any fixed effects, i.e., including only firm characteristics. In column 2, we add year fixed effects. In column 3, we control year and district effect. Column 4 reports the results when we extend the basic model by controlling year, district, and industry fixed effects. Standard errors are clustered along district-year. Column 4 is our preferred specification.

The results show that exposure to El Niño induced drought has a negative effect on firm output, which is statistically robust across the different specifications. Results in column 4 shows that the magnitude of the negative effect of El Niño exposure on revenues is substantial. Specifically, the coefficient of El Niño is associated with a decrease in sales of approximately 47% for the exposed firms. This is in line with our expectation that firms exposed to the El Niño drought shock tend to experience a decrease in sale due El Niño's potential adverse effects on weather patterns and agricultural production, along with changes in consumer behavior and economic uncertainty.

Concerning the other control variables, our results show that engagement in international trade through export and import is associated with higher sales. Moreover, companies owned by foreign investors exhibit greater sales performance, with sales approximately 19% higher than those owned by local investors. Furthermore, as companies age, their sales tend to rise.

Table 2: Impact of El Niño on firm output

	(1)	(2)	(3)	(4)
El Niño (DiD coef.)	-0.760***	-0.959***	-0.512***	-0.645***
	(0.139)	(0.146)	(0.117)	(0.105)
Export	1.678***	1.715***	1.369***	0.955***
	(0.173)	(0.172)	(0.207)	(0.202)
Import	0.836***	0.807***	0.867***	0.737***
	(0.0861)	(0.0812)	(0.0779)	(0.0696)
Foreign ownership	0.947***	0.965***	0.675***	0.339**
	(0.148)	(0.144)	(0.152)	(0.123)
ln(age)	0.496***	0.505***	0.796***	0.748***
	(0.0798)	(0.0765)	(0.0807)	(0.0619)
Constant	14.24***	14.28***	13.34***	13.63***
	(0.24)	(0.230)	(0.242)	(0.189)
Year FE	No	Yes	Yes	Yes
District FE	No	No	Yes	Yes
Industry FE	No	No	No	Yes
Observations	3965	3965	3951	3950
R-squared	0.127	0.140	0.344	0.471

Notes: This table reports coefficient of El Niño. Standard errors are cluster along district-year categories. The main independent variable is firms' sale in the year and district. We add 1 to zeros in log transformation. The nominal monetary variables are converted into constant prices using GDP deflator data from World Development Indicators. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

5.2 Productivity

Next, we examine the impact of El Niño on firm productivity. We use two related measures of productivity. The first is labor productivity and the second is Total factor productivity (TFP). Labor productivity is measured as output over employment. TFP is a measure of efficiency in production, i.e. how much output is obtained from a given set of inputs (Syverson, 2011). TFP is a widely used measure of productivity. It is also the portion in output that is beyond what the factors of production contribute.

Labor productivity and TFP can be affected by the El Niño shock in several ways. Firstly, extreme drought can disrupt the supply of agricultural inputs crucial for the food and beverage manufacturing sector, leading to production delays and increased costs, negatively impacting TFP. Secondly, scarcity of water and resources during droughts can raise operating costs for manufacturing firms, further reducing TFP. Fourthly, adverse weather conditions can affect productivity by,directly influencing working conditions, disrupting production processes, causing economic uncertainties, and creating logistical challenges. These factors collectively result in decreased physical well-being, reduced energy levels, impaired concentration, and economic pressures, leading to lower revenue generated per worker. Fifthly, the uncertainty caused by extreme weather events can lead to reduced investment in modern technologies, affecting TFP in the long run. Lastly, disruptions in the supply chain can lower TFP as firms struggle to maintain regular operations.

Table 3 reports the effect of El Niño on TFP. The estimation results are consistent with our prior expectations. We find a robust significant decrease in TFP for the El Niño shock-exposed firms across the different specifications. In the preferred (full) specification (Column 4), the coefficient for El Niño is -0.487, equivalent to a 38 percent reduction in firm's TFP. This effect is statistically significant at the 1% level. We also find that companies involved in international trading (export and import) tend to be more productive compared to companies that don't join the global market. Also, companies owned by foreign investors are more productive than those owned by local investors. As companies get older, they also tend to become more productive.

Table 4 reports El Niño impact on labor productivity. We find that El Niño exposure on labor productivity, defined as revenues over employment is negative and significant at 1% level. Based on our preferred (full) specification (column 4), the magnitude of the negative effect of El Niño exposure on labor productivity is substantial: on average, firms exposed to El Niño experience a 33% decrease in labor productivity compared to firms that are not exposed to El Niño.

Table 3: Impact of El Niño on Firm Total Factor Productivity (TFP)

	(1)	(2)	(3)	(4)
El Niño (DiD coef.)	-0.575***	-0.660***	-0.350***	-0.451***
	(0.0908)	(0.0987)	(0.0825)	(0.0750)
Export	1.078***	1.098***	0.893***	0.735***
	(0.131)	(0.132)	(0.154)	(0.150)
Import	0.518***	0.515***	0.582***	0.532***
	(0.0645)	(0.0631)	(0.0619)	(0.0549)
Foreign ownership	0.388**	0.396**	0.212	0.0295
	(0.131)	(0.133)	(0.133)	(0.133)
ln(age)	0.0377	0.0395	0.264***	0.309***
	(0.0559)	(0.0551)	(0.0575)	(0.0532)
Constant	10.92***	10.94***	10.21***	10.16***
	(0.168)	(0.165)	(0.170)	(0.156)
Year FE	No	Yes	Yes	Yes
District FE	No	No	Yes	Yes
Industry FE	No	No	No	Yes
Observations	3808	3808	3789	3788
R-squared	0.0804	0.0863	0.290	0.429

Notes: This table reports coefficient of El Niño. Standard errors are cluster along district-year categories. The main independent variable is firms' Total Factor Productivity (TFP), which is estimated using Levinsohn and Petrin (2003) approach. The nominal monetary variables are converted into constant prices using GDP deflator data from World Development Indicators. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

Table 4: Impact of El Niño on Firm Labor Productivity

	(1)	(2)	(3)	(4)
El Niño (DiD coef.)	-0.528***	-0.730***	-0.298***	-0.407***
	(0.0929)	(0.102)	(0.0867)	(0.0790)
Export	0.571***	0.596***	0.523***	0.415***
	(0.114)	(0.115)	(0.137)	(0.118)
Import	0.414***	0.423***	0.419***	0.431***
	(0.0596)	(0.0584)	(0.0550)	(0.0485)
Foreign ownership	0.227*	0.232**	0.158	0.0513
	(0.0889)	(0.0892)	(0.0940)	(0.0907)
ln(age)	-0.152*	-0.136*	0.112	0.162**
	(0.0617)	(0.0602)	(0.0618)	(0.0523)
Constant	13.07***	13.08***	12.27***	12.16***
	(0.181)	(0.180)	(0.179)	(0.149)
Year FE	No	Yes	Yes	Yes
District FE	No	No	Yes	Yes
Industry FE	No	No	No	Yes
Observations	3929	3873	3857	3856
R-squared	0.0243	0.0682	0.278	0.392

Notes: This table reports coefficient of El Niño. Standard errors are cluster along district-year categories. The main independent variable is firms' Labour Productivity (LP. The nominal monetary variables are converted into constant prices using GDP deflator data from World Development Indicators. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

5.3 Employment

So far, we have documented that firms exposed to El Niño have registered a decrease to their output, TFP and labor productivity. In this section, we examine whether these changes have any impact on employment. Table 5 provides an answer to this question: The results in all specification, except the basic model – for which the effect is insignificant, show that on average El Niño exposed firms have registered a decrease in employment at 10 significance level. Particularly, using our preferred (full) specification, drought exposed firms experienced a 15% lower employment. The result is statistically significant at 10% level.

Table 5: Impact of El Niño on Firm employment

	(1)	(2)	(3)	(4)
El Niño (DiD coef.)	-0.142	-0.155*	-0.173*	-0.163*
	(0.0808)	(0.0755)	(0.0752)	(0.0708)
Export	1.064***	1.074***	0.815***	0.516***
	(0.0938)	(0.0929)	(0.102)	(0.105)
Import	0.408***	0.375***	0.457***	0.304***
	(0.0478)	(0.0439)	(0.0464)	(0.0417)
Foreign ownership	0.919***	0.937***	0.699***	0.377***
	(0.0897)	(0.0870)	(0.0944)	(0.0771)
ln(age)	0.590***	0.585***	0.608***	0.529***
	(0.0441)	(0.0439)	(0.0483)	(0.0405)
Constant	1.344***	1.378***	1.307***	1.643***
	(0.126)	(0.124)	(0.142)	(0.123)
Year FE	No	Yes	Yes	Yes
District FE	No	No	Yes	Yes
Industry FE	No	No	No	Yes
Observations	3950	3950	3933	3932
R-squared	0.174	0.187	0.346	0.459

Notes: This table reports coefficient of El Niño. Standard errors are cluster along district-year categories. The main independent variable is firms' employment. The nominal monetary variables are converted into constant prices using GDP deflator data from World Development Indicators. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6 Mechanisms

In this section, we discuss how the production inputs mechanism can account the effect of El Niño exposure on the firm's economic performance. To understand this, we analyze the impact of El Niño exposure on company's use of total raw materials, local raw material and imported raw material. In this section, we estimate equation 2.

6.1 Total raw material usage

In Table 6, we estimate the effect of El Niño exposure on the firm's use of raw material inputs. The coefficients for El Niño exposure in columns (1) through (4) are consistently negative, indicating that when a firm's exposed to El Niño, has reduced total raw material usage. For example, the coefficient of El Niño presented in column (4) suggest that El Niño exposure reduce firms input usage by 53%.

This is because firms, primarily in the food and beverage sector, that are exposed to El Niño—a weather phenomenon characterized by extreme events like droughts—often encounter difficulties in securing sufficient raw materials due to disruptions in supply chains and crop failures. This scarcity can result in a decrease in the utilization of raw materials as companies strive to maintain their regular production operations. The erratic weather conditions can also lead to higher raw material costs stemming from supply shortages and elevated prices.

Table 6: Impact of El Niño on total raw material usage

	(1)	(2)	(3)	(4)
El Niño (DiD coef.)	-0.981***	-1.207***	-0.602***	-0.763***
	(0.143)	(0.143)	(0.116)	(0.105)
Export	1.365***	1.407***	1.122***	0.851***
	(0.184)	(0.183)	(0.212)	(0.211)
Import	0.768***	0.731***	0.831***	0.751***
	(0.0909)	(0.0852)	(0.0823)	(0.0753)
Foreign ownership	0.987***	1.011***	0.605***	0.334**
	(0.141)	(0.138)	(0.142)	(0.128)
ln(age)	0.290***	0.298***	0.642***	0.639***
	(0.0831)	(0.0797)	(0.0790)	(0.0717)
Constant	14.43***	14.49***	13.33***	13.46***
	(0.244)	(0.234)	(0.236)	(0.216)
Year FE	No	Yes	Yes	Yes
District FE	No	No	Yes	Yes
Industry FE	No	No	No	Yes
Observations	3992	3992	3978	3977
R-squared	0.110	0.129	0.343	0.444

Disruptions in operations caused by El Niño, including power outages, can lead to reduced production capacity and subsequently lower raw material consumption. Previous evidence highlights the widespread impact of the 2015-16 El Niño drought in Ethiopia, which caused crop failures, livestock deaths, and loss of livestock production (FAO, 2016; UNICEF, 2016; Philip et al., 2018). This, in turn, could contribute to shortages in raw materials that adversely affect the performance of firms.

6.2 Local versus imported inputs

Here, we aim to test whether El Niño exposure has differential impact on sourcing of intermediate inputs from domestic or imported sources. In section 6.1, we find that El Niño exposure has resulted in lower input usage, which could be domestic input or foreign or both. We hypothesize that firms exposed to El Niño drought conditions will show a decrease in the usage of local inputs (raw materials) due to potential shortages in domestic sources. This decrease might lead to an increase in the import of inputs to compensate for the scarcity of local raw materials.

In Table 7 and 8, we show the results of the impact of El Niño on local and imported raw material usage, respectively. The coefficient of El Niño exposure in Column 4 of Table 7 show that firms exposed to El Niño drought conditions tend to reduce their usage of local raw materials by approximately 45%. This result supports our hypothesis that El Niño droughts have a negative effect on firm outcomes through the usage of local raw materials. Firms facing El Niño conditions are likely experiencing shortages in domestic raw materials due to adverse weather conditions, which in turn leads to a reduction in their usage. This is in line with the logic that El Niño-related droughts can negatively impact the availability and quality of local resources.

Interestingly, when we regress value of imported raw materials on El Niño exposure, the effect is not significantly different from zero for our preferred (full) specification, although significant at 5% significance level for the basic specification and at 10%

when we include time fixed effects (Table 8). This means that El Niño induced drought doesn't seem to lead to a significant change in how much imported raw materials companies use.

Furthermore, in Table 9, we assess whether firms switch from using local inputs to using foreign input following El-Nino exposure. We did this by estimate the effect of El Niño induced drought on the ratio of foreign to local raw materials as a dependent variable in Table 9. El Niño. The estimated coefficient is not statistically significant, meaning that El Niño exposed firms don't seem to make a significant change in the way they use local and foreign raw materials.

Therefore, the primary way in which El Niño adversely affects firm performance is by leading to a reduction in the usage of local raw materials. The results suggests that when El Niño conditions occur, firms tend to significantly decrease their usage of local raw materials. However, firms don't seem to counterbalance this reduction by increasing their use of imported raw materials. One plausible explanation could be the potential shortage of financial resources, which might hinder their ability to increase their imports. Consequently, this reduction in local raw material usage, among other possible channels, may contribute to an overall negative impact on firm performance during El Niño events. This is consistent with the findings based on the survey data: About 46% of firms ranked the difficulty of accessing raw material inputs as a primary challenge they faced in their business operations following El-Nino shock. (Figure 2) and 63% of firms cited shortage of raw- material because of El- Nino as a significant disruption to their business activity (Figure 3).

Table 7: Impact of El Niño on local raw material usage

	(1)	(2)	(3)	(4)
El Niño (DiD coef.)	-0.789***	-1.003***	-0.474***	-0.610***
	(0.151)	(0.153)	(0.135)	(0.126)
Export	1.451***	1.494***	1.219***	0.966***
	(0.189)	(0.188)	(0.222)	(0.224)
Import	-0.0427	-0.0791	0.0393	0.0227
	(0.0995)	(0.0919)	(0.0896)	(0.0868)
Foreign ownership	0.962***	0.974***	0.592***	0.370**
	(0.153)	(0.150)	(0.149)	(0.143)
ln(age)	0.338***	0.345***	0.658***	0.629***
	(0.0865)	(0.0830)	(0.0833)	(0.0810)
Constant	14.23***	14.29***	13.23***	13.39***
	(0.258)	(0.246)	(0.251)	(0.246)
Year FE	No	Yes	Yes	Yes
District FE	No	No	Yes	Yes
Industry FE	No	No	No	Yes
Observations	3802	3802	3785	3784
R-squared	0.0649	0.0850	0.286	0.354

Table 8: Impact of El Niño on imported raw material usage

	(1)	(2)	(3)	(4)
El Niño (DiD coef.)	-0.864**	-0.770*	-0.245	-0.365
	(0.276)	(0.302)	(0.256)	(0.248)
Export	1.381***	1.338***	0.949**	0.271
	(0.317)	(0.319)	(0.342)	(0.327)
Import	0.0203	-0.0273	-0.0392	-0.503
	(0.969)	(0.955)	(0.630)	(0.763)
Foreign ownership	1.828***	1.747***	1.269***	0.694**
	(0.249)	(0.251)	(0.271)	(0.230)
ln(age)	0.373*	0.343*	0.668***	0.796***
	(0.157)	(0.154)	(0.161)	(0.146)
Constant	12.72***	12.83***	11.84***	12.05***
	(1.064)	(1.040)	(0.809)	(0.898)
Year FE	No	Yes	Yes	Yes
District FE	No	No	Yes	Yes
Industry FE	No	No	No	Yes
Observations	2102	2102	2080	2080
R-squared	0.0434	0.0681	0.275	0.400

Table 9: Impact of El Niño on ratio of local to imported raw material usage

	(1)	(2)	(3)	(4)
El Niño (DiD coef.)	-0.621**	-0.315	-0.0974	-0.131
	(0.210)	(0.242)	(0.304)	(0.311)
Export	0.00806	-0.0752	0.0263	-0.139
	(0.288)	(0.294)	(0.345)	(0.361)
Import	-1.199	-1.390	-1.097	-1.136*
	(0.678)	(0.717)	(0.609)	(0.525)
Foreign ownership	0.872***	0.792**	0.714*	0.357
	(0.241)	(0.243)	(0.296)	(0.267)
ln(age)	-0.0473	-0.0824	-0.0106	0.172
	(0.148)	(0.144)	(0.175)	(0.165)
Constant	-0.0474	0.169	-0.391	-0.828
	(0.785)	(0.803)	(0.766)	(0.707)
Year FE	No	Yes	Yes	Yes
District FE	No	No	Yes	Yes
Industry FE	No	No	No	Yes
Observations	1912	1912	1886	1886
R-squared	0.00990	0.0307	0.154	0.219

6.3 Additional mechanisms

In this section, we present results from survey of surviving firms. Figure 2 shows the list of potential channels through which El-Nino affects firms in food and beverage sector. 46% of firms ranked the difficulty of accessing raw material inputs as a primary challenge they faced in their business operations following El-Nino shock. This is consistent with the results in Table 5 (section 6). Similarly, close to 20% of firms reported shortage of electricity as the major challenge for their business operation during the period of El Niño drought. The third most common main challenge, reported by 18% of establishments, was the increase in price of raw materials, meaning that raw materials could be available but at a higher price and hence firms need to cut the amount of raw material use.

Furthermore, we have also asked firms to rate the difficulties resulting from shortage of raw materials due to challenges of EL-Nino shock. Specifically, we ask businesses to rate the disruptions on raw material supply as "Not a concern "," Minor Disruption, Moderate Disruption ", and "Very severe disruption". Figures 3 presents the result associated with this question. Consistent with previous results, Figure 3 shows that shortage of raw materials is considered as a very sever or major disruption by 16% and 47% of firms respectively. In sum, 63% of firms cited shortage of raw- material as a result of El- Nino as a significant disruption to their business activity.

Figure 2: Main channels through which El-Nino affects firms in food and beverage sector

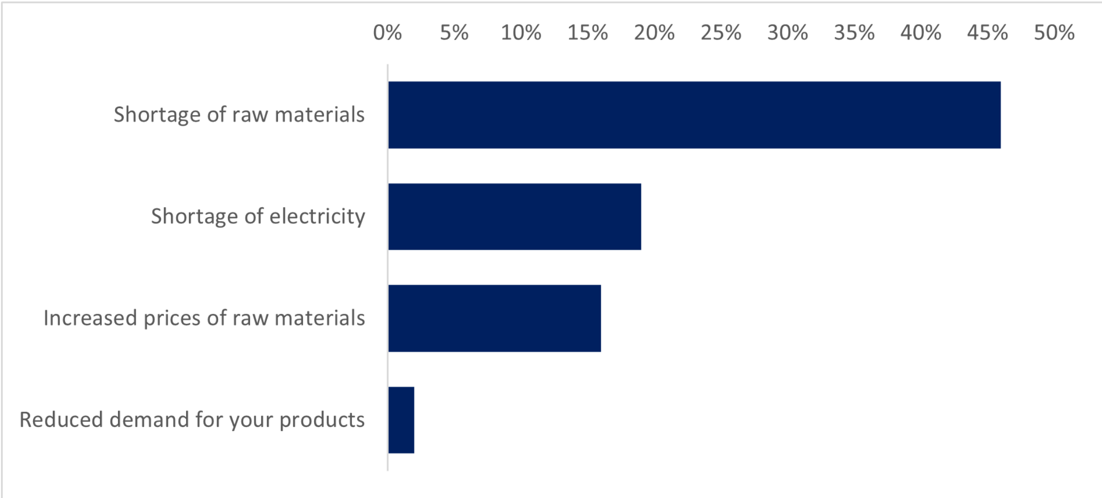
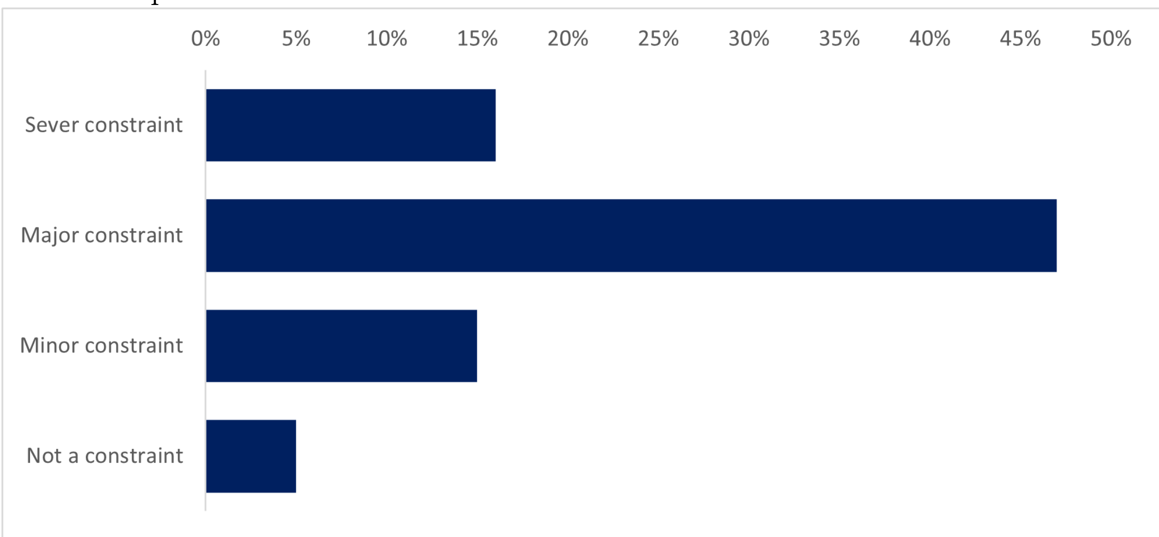


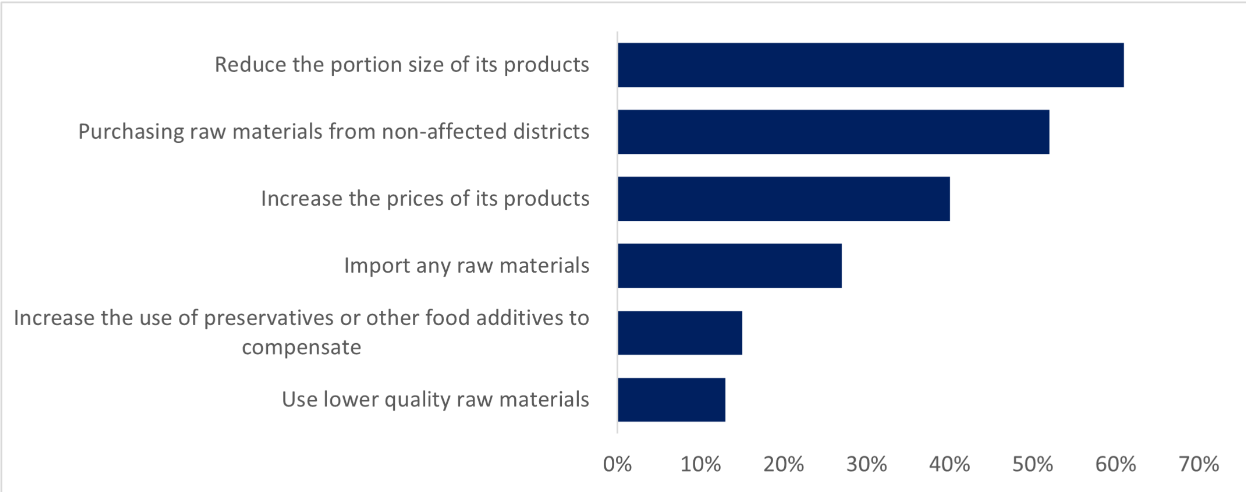
Figure 3: How would you rate the difficulties (disruptions) resulting from raw material inputs due to El-Nino?



7 Coping mechanism

In the survey we have asked firms what type of coping mechanisms they used to mitigate its negative impact of El-Nino. We find that reducing the production capacity – to cut costs - was cited as a primary coping strategy against the negative consequences of the extreme climate shock (EL-Nino). More specifically, more than 60% of firms reported that they reduce their production capacity. The second and third most used coping strategies are purchasing raw materials from El-Nino non exposed areas and increase the price of its product to compensate for the possible loss.

Figure 4: How would you rate the difficulties (disruptions) resulting from raw material inputs due to El-Nino?



8 Policy responses

We have asked firms what actions you believe the government should take to mitigate the impact of future droughts on small food and beverage firms. The most frequently cited measure, by 83% of firms, is the government's role in encouraging suppliers to develop drought-resistant crops. This overwhelming support underscores the importance of sustainable agricultural practices in buffering against drought-related disruptions. Additionally, 68% of firms suggest establishing a contingency fund for drought management. Around 65% of firms stress the significance of improved transportation to ensure smoother access to both inputs and product distribution. Overall, these findings spotlight a call for comprehensive, multi-pronged government interventions that encompass sustainable agriculture, financial support mechanisms, training, and logistical improvements to enhance resilience within the food and beverage sector during droughts.

Table 10 sheds light on the preferred government policies and initiatives identified by firms in the food and beverage sector to enhance their resilience in the face of droughts. The most widely cited measure, with 76% of firms supporting it, is providing access to credit. Notably, 68% of firms advocate for training programs dedicated to drought management planning, indicating a desire for enhanced preparedness through knowledge-building. Additionally, 61% of firms emphasize the importance of tax incentives for those who invest in drought management, highlighting the potential positive impact of financial incentives on fostering drought resilience measures. Furthermore, the endorsement of subsidies for drought-resistant practices by 60% of firms underscores the industry's emphasis on proactive and sustainable agricultural approaches to withstand drought conditions.

Table 10: What actions do you believe the government should take to mitigate the impact of future droughts on small food and beverage firms?

Government Actions	Percentage
Encourage drought-resistant crop development	83%
Establish a contingency fund for drought management	68%
Improve transportation to access input and product	65%
Provide financial support to affected firms	37%
Other	4%

Table 11: What policies or initiatives do you believe the government should implement to improve the resilience of small food and beverage firms during droughts?

Government Policies/Initiatives	Percentage
Access to credit for drought-affected firms	76%
Training programs for drought management planning	68%
Tax incentives for firms investing in drought management	61%
Subsidies for drought-resistant practices	60%
Other	2%

9 Summary and conclusions

This paper examines the causal impacts of the El Niño induced drought on the performance of food and beverage manufacturing firms in Ethiopia. Specifically, we ask three research questions: First, does El Niño induced drought affect the performance of food and beverage manufacturing firms—measured in terms of firm's productivity, sale, and employment? Second, what are the mechanisms through which extreme droughts affect firm's performance? Third, what strategies do the surviving firms adopt to cope and adapt with droughts? Using spatial and temporal variation of El Niño across districts, we employed difference-in-difference estimation.

We provide three main findings. First, El Niño exposed firms experience decrease in sales by 47%, total factor productivity (TFP) by 38% and labor productivity by 33% and employment by 17% relative to the control group. Second, the mechanisms through which El Niño exposure affects firms' performance is through its effect on firm's use of raw material inputs. We find that companies facing El Niño-related disruptions encounter challenges in securing adequate raw materials due to supply chain breakdowns because of crop failures. This scarcity leads to reduced raw material usage as firms strive to maintain production. We find that exposure to El-Nino results a reduction of using local raw material by more than 50% reduction. Third, reducing production, purchasing raw materials from non-affected areas, and increasing the price of products the three most used coping strategies to mitigate the negative effect of El Niño. In addition, access to credit, training programs dedicated to drought management planning, and tax incentives for those who invest in drought management are cited as the top three preferred policy initiates that government should implement to improve the resilience of food and beverage firms during droughts.

The empirical findings of our study have direct implications for policy development. First, firms need to be supported with accessing raw materials (through improving supply chain resilience and exploring alternative raw material sourcing strategies) in time of drought to cope with the droughts and to minimize the negative effects of their performance and economy wide effects of reducing employment and increasing prices for products. Second, there is a need for interventions to enhance the resilience and adaptive capacity of food and beverage firms so that the firms will not be affected significantly by droughts. Such interventions include facilitating access to credit, investing on distribution infrastructure (e.g. roads) and agricultural production infrastructure (e.g. irrigation), offering training programs for drought management planning, and providing tax relief to encourage investments in drought management.

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Figure 1: Trend for total Sales, export sales, and production by drought affected status.

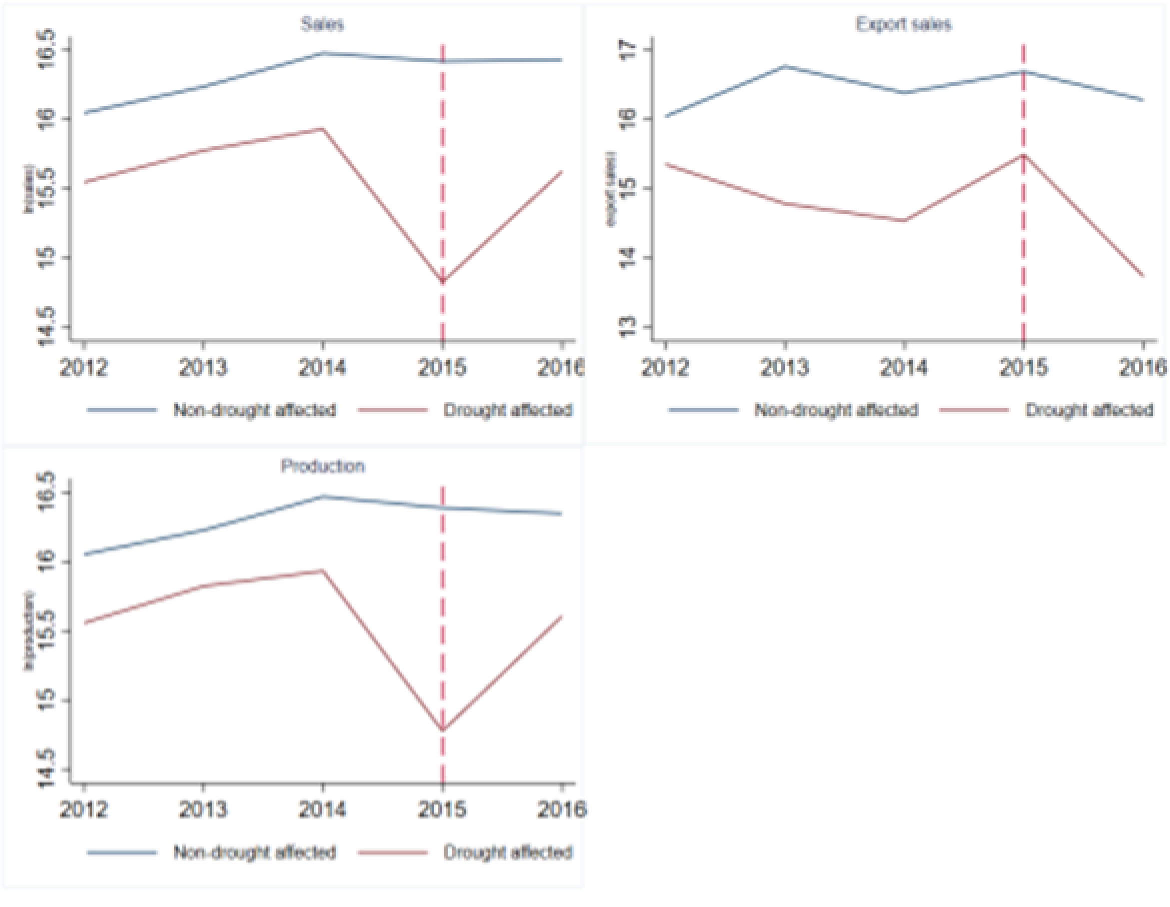

Figure 2: TTrend for productivity (total factor and labor) by drought affected status

Figure 3: Trend for employment and wage bill by drought affected status

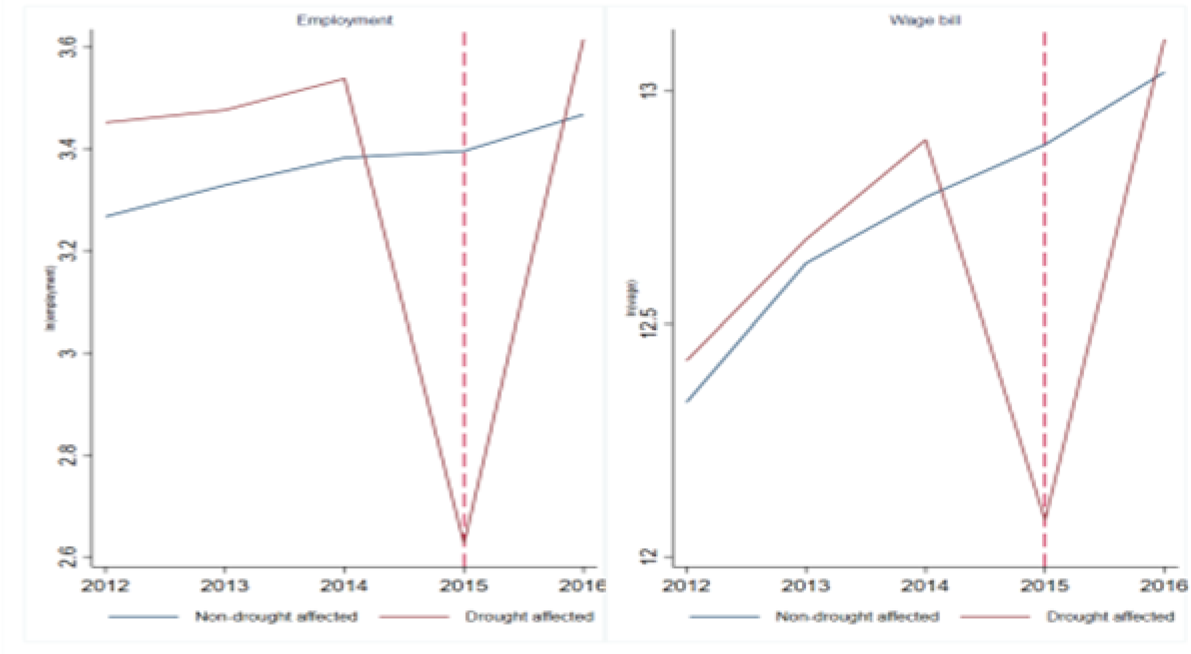

Figure 4: Trend for raw material use by drought affected status