Policy Research Working Paper 10923

Thirsty Business

A Global Analysis of Extreme Weather Shocks on Firms

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WORLD BANK GROUP
Middle East and North Africa Region &
Planet Vice Presidency
September 2024

Policy Research Working Paper 10923

Abstract

Using global data from the World Bank's Enterprise Surveys that includes the precise geo-location of surveyed firms, this paper examines how dry spells and precipitation shocks influence firm performance. The study finds that firms in areas that experience dry spells have lower performance in terms of sales. This is particularly true for smaller firms and those in developing economies. A higher number of extreme dry days also increases the chances that a firm will exit the market. The main channels are largely through labor productivity and infrastructure service disruptions such as water and power outages. There is also some evidence of limited access to finance due to negative precipitation shocks. Governance may be an exacerbating factor, with negative precipitation shocks increasing exposure to corruption. Yet, there is also some indication that digitally connected and innovative firms are more resilient to negative precipitation shocks. Process innovation, website ownership, and use of technology licensed from foreign firms mediate the effects of negative precipitation shocks on firm performance. However, there is little evidence of adaptation. Negative precipitation shocks have no effect on the presence of green management practices or green investments for a subset of firms for which such data is available.

This paper is a product of the Office of the Chief Economist, Middle East and North Africa Region and the Office of the Chief Economist, Planet Vice Presidency. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://www.worldbank.org/prwp. The authors may be contacted at aislam@worldbank.org.

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JEL Codes: Q1, Q5, H54, O14, D73

Keywords: Precipitation shocks, firm productivity, firm-level analysis, climate change

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1. Introduction

The variability of rainfall, defined as deviations from its long-term mean, is a growing challenge. Over the past three decades, 1.8 billion people, or approximately 25 percent of humanity, have endured abnormal rainfall episodes each year, whether it was a particularly wet or unusually dry year (Damania et al., 2017). With climate change, deviations from trends are projected to become more pronounced and frequent. Droughts and adverse water supply shocks are a particular concern, with drought frequency and duration rising by nearly a third globally since 2000 (The United Nations Convention to Combat Desertification (UNCCD), 2022) with lasting negative impacts on economic growth in developing economies (Zaveri et al., 2023; Russ, 2020).

While the effects of extreme weather events on agriculture and rural areas have received considerable attention, there are also consequences for cities that may have significant implications. The last few years have seen several major cities like Cape Town in South Africa, São Paolo in Brazil, and Chennai in India, face "day zero" type events in which water supplies become threateningly low, with countless more medium-size and small cities experiencing intermittent water supply and water shortages (Zaveri et al., 2021; Singh et al., 2021). Water scarcity can significantly impact households, public services, and critical infrastructure systems, affecting workers and entire communities (Damania et al., 2017; Hyland and Russ, 2019; Islam and Hyland, 2019).

The varied effects of extreme weather events on the private sector are not well understood. Firms are a critical engine of economic growth. They generate jobs, provide essential products and services, and encourage innovation. They link cities and towns to global markets. This study explores the effect of droughts (negative precipitation shocks) on a global sample of firms in urban centers. The study finds that negative precipitation shocks hurt firm performance in terms of sales. This is particularly true for smaller firms and those in developing economies. Firms that experience negative precipitation shocks are also more likely to exit the market. An additional extreme dry day leads to a 0.6 percent reduction in sales. The average number of extreme dry days in the sample is 6.7 days such that an increase in extreme dry days of this amount translates to a 3.8 percent reduction in sales. At the sample maximum of 86 days or about 3 months of extreme dry days, the loss in sales can rise to 48.6 percent. Since extreme dry days also lead firms to exit, these estimates may represent an underestimate of the overall impact.

The literature has identified several channels through which extreme weather events could affect firms. One channel is through human capital. Hot days could lead to more absenteeism or lower the labor productivity of workers (Somanathan et al., 2021). Another channel is through infrastructure. Negative precipitation shocks (droughts) increase the intensity of water outages that hurt sales (Islam and Hyland, 2019). Droughts may also increase the frequency of power outages (Desbureaux and Rodella, 2019). Access to finance is another channel identified by the literature. Frequent climate shocks might affect the ability of banks to predict outcomes, leading to an increase in interest rates due to additional risk which could, in turn, increase the cost of capital (Kling et al., 2021). Extreme weather events could also lead to balance sheet erosion as firms that experience monetary losses from shocks become more leveraged as they are more likely to get their loan applications rejected and be seen as less creditworthy (Benincasa et al., 2024). Weather shocks can also create liquidity shortages and increase loan defaults, deteriorating credit scores and access to future credit (Aguilar-Gomez et al., 2023).

The effects of extreme weather events on investment, however, are not obvious. On one hand, if weather shocks limit access to finance, firms are less likely to invest. On the other hand, firms affected by weather shocks are more likely to invest in fixed assets as they replenish damaged capital (Benincasa et al., 2024). New investments can also lead to vintage effects where replenishment of capital means newer equipment with a lower environmental footprint. Alternatively, firms may become environmentally aware and therefore engage in green investments or green management practices.

The Enterprise Surveys allows for the possibility to test some of these channels. The main channels are largely infrastructure service disruptions such as water and power outages. There is some evidence of effects through labor productivity (sales per worker) and also limited access to finance – negative precipitation shocks decrease the likelihood than firms use banks to financing working capital and have access to overdraft facilities. A new channel uncovered in this study is governance. The intensity of negative precipitation shocks increases exposure to corruption. While there is no effect uncovered regarding weather shocks and investment in machinery and equipment, this could be due to the countervailing effects of limited access to finance and the need to replace damaged capital. However, extreme dry days do increase the probability of investing in land and buildings. Firms that are innovative in terms of process, have website ownership, and use technology licensed from foreign firms experience more muted effects of extreme dry days on firm performance. There is also some evidence that digital technologies and innovation can buffer against climate shocks (Zhao and Parhizgari, 2024; Liu et al., 2023). Finally, for a cross-section of 2019 surveys largely conducted in the Middle East and North Africa and Europe and Central Asia, a green module included in the survey instrument captures green investments and green management practices. This study leverages this new data for a subset of firms where it is available but finds no correlation between precipitation shocks and green management practices or green investments. One explanation could be that firms might adopt such practices only after repeated dry spells over time. However, these survey questions are limited. Adoption of green management practices or investments are captured through a binary variable – where a value of 1 means adoption and 0 implies no adoption - that pertains only to three years prior to the survey. Hence a firm that adopted any green management practices or made green investments 4 years prior may be coded as a zero. Therefore, these findings should be interpreted with care.

Several policy implications can be drawn from the findings of the study. First, the results reveal that smaller firms, and those in developing economies are more susceptible to climate shocks. Building resilience among smaller firms and those in developing economies is essential. Second, water and power infrastructure are central to the narrative. As climate change makes precipitation patterns more variable and unpredictable, investments in public water and power infrastructure systems are an important way in which governments can help firms adapt. Second, institutions matter, and governance may play a critical role in how firms fare after extreme weather events. Third, encouraging innovation is one way to build resilience in firms. Finally, extreme weather events may not necessarily lead firms to adapt, and thus other policy interventions would be needed to increase green management practices and green investments.

In summary, the study makes the following contributions to the literature. First, the study provides a global analysis of extreme weather events and firm performance. Second, it tests several channels through which the effects of negative precipitation shocks can be identified in the literature while proposing a new channel related to governance. Third, the study explores the types of firms that are more resilient to shocks. And fourth, the study uses a unique dataset to dispel the notion that firms may become environmentally aware after climactic shocks.

The rest of the paper is structured as follows. Section 2 describes the data and the empirical approach. Section 3 provides the results with robustness checks. Section 4 concludes.

2. Empirical Approach

2.1 Data

2.1.1 Enterprise Surveys

The main data source is cross-sectional firm-level surveys across the world from the World Bank's Enterprise Surveys (ES). The ES are nationally representative surveys of private formal (registered) firms with 5 or more employees and cover manufacturing and services firms largely collected via face-to-face interviews with business owners or top managers. Our sample for the analysis is restricted to firms that have geo-located information. The final sample consists of about 88,000 firms (depending on the specification) across 174 surveys over 118 economies in the time period 2009-2019. Summary statistics are provided in table A1. The full list of countries and survey years are presented in table A2. In addition, for countries where there were several rounds of surveys, we can track whether the firm exited the market regardless of whether they were re-interviewed in successive waves. We can obtain information on firm exit across 55 countries.

The ES methodology includes a consistent definition of the universe of inference, a standard sampling methodology, a standardized survey instrument, and a uniform methodology of implementation. The selection of firms in each country is achieved by stratified random sampling with three levels of stratification: sector, size, and location within the country. Sampling weights are used to correct for unequal probability of selection, ineligibility and non-response. The data are largely collected using Computer-Assisted Personal Interviewing (CAPI) software. The CAPI software collects geo coordinates of the firm's location that we use to match rainfall and temperature data with the firm-level data. To maintain anonymity of the respondents, the geo-codes are masked around a 2km radius.

The surveys are implemented uniformly across countries. Formal training sessions of supervisors and enumerators are undertaken to ensure the best practices are employed consistently. Quality control checks are implemented to guarantee the quality of the data throughout the data collection process. Consistency checks are employed for 10% and 50% batches of the data during the survey to facilitate callbacks to respondents to be undertaken when necessary to verify information. Information on the Enterprise Surveys global methodology and on the sample design and weights computation is available on the website http://www.enterprisesurveys.org. The data have been widely used by several studies analyzing the private sector in developing economies (Besley & Mueller, 2018; Chauvet & Ehrhar, 2018; Hjort & Poulsen, 2019).

2.1.2 Precipitation Shocks

To measure precipitation shocks, we use reanalysis data produced by the European Centre for Medium-Range Weather Forecasts (ECMWF). More specifically, we use the new land component of the fifth generation of European ReAnalysis (ERA5), hereafter referred to as ERA-5 Land dataset (Muñoz-Sabater et al., 2021). This dataset is produced by the ECMWF as part of the ongoing operations of the Copernicus Climate Change Service (C3S), a subdivision of the Copernicus program, which is the Earth Observation arm of the space program established by the European Commission. ERA5-Land is a global-scale dataset that contains hourly records of more than 50 key meteorological variables (including precipitation) at a 9 km spatial resolution over the period from 1950 to the present. These records are produced by running downscaled meteorological forcings obtained from the ERA5 climate reanalysis[1] through a high-resolution land surface process model developed by ECMWF. For our application, we use the daily aggregated version of the dataset, which is freely provided on the Copernicus Climate Data Store (CDS) and accessible via Google Earth Engine.

There are several key features of the ERA5-Land data. First, as detailed below, constructing the precipitation shock measure we favor in our analysis involves normalizing daily rainfall observations against a day-of-year and grid-cell specific climate distribution. Computing the relevant moments of these localized distributions requires a long, consistently measured, time series of daily rainfall data. Reanalysis datasets like ERA5-Land have both these features. Second, with a resolution of 9 km, the ERA5-Land data allow us to measure precipitation shocks precisely in the exact areas where the firms in the Enterprise Surveys are located. Finally, with its complete global coverage, using ERA5-Land means we can construct shock measures for any location in the world, and thus for every single firm in the ES data. By contrast,

[1] For an overview of ERA5, see (Hersbach et al., 2020).

rainfall datasets produced by long-running Earth-observing satellites are often lower resolution, have spatial or temporal gaps in data coverage, and exhibit variation in the fidelity and methodology of measurements over time.

In our empirical analysis, our preferred measure of precipitation shocks is a variable we call `dry days', which varies at the annual and secondary sub-national administrative unit (ADM2) level. To construct this variable, we start with the daily total precipitation values observed in all ERA5 grid cells that are contained within the ADM2 units where we observe at least one firm in the ES data. Then, to focus on contemporary climate and match the temporal coverage of the ES data, we restrict the daily data to the period from 1990 to 2021. We then compute the long-run (1990-2021) mean and standard deviation for each day of the year in each grid cell. Using these moments of the local climate distribution, we then classify whether the precipitation observed on each day is more than 1 standard deviation below the long-run average for that particular day of the year. Days that satisfy this condition are considered `dry' days. Finally, we sum across days within grid-years and average across ERA5 grid cells within ADM2 units to arrive at the final measure of dry days that we use in our primary empirical analysis. In many of our specifications, we also include an analogous measure of `wet' days, which captures the number of days in a year where rainfall was more than 1 standard deviation above the long-run day-of-year average.

Previous studies have often measured rainfall shocks in terms of (normalized) deviations of total cumulative annual or seasonal rainfall from location-specific long-run averages. Standardized drought indices, such as the SPEI or PDSI, have also been widely used. Relative to these standards, our dry (wet) days measure has two key advantages. First, our measure captures extreme dryness (wetness) events even when they occur over a period of just a few days (or even just a single day). This helps us identify nonlinear effects which can be diluted when weather outcomes are more coarsely averaged over time.[2] Second, by normalizing daily rainfall values relative to a location- and day-of-year specific climate distribution, our measure effectively summarizes deviations in the timing of rainfall throughout the year. For example, a year where precipitation is exactly equal to the long-run daily average on every day of the year would have zero dry days and zero wet days. But a year with the same total annual precipitation, but where the timing of rainfall throughout the year is significantly shifted, would have many dry and wet days. As a result, when we use dry (wet) days as our measure of precipitation shocks, we can capture effects on firms that result from disruptions to the normal timing of rainfall throughout the year.

2.2 Empirical Approach

The empirical approach exploits cross-sectional variation in the ES data combined with precipitation shocks at the ADM2 geographical unit, while accounting for sub-national ADM1 fixed effects. The main analysis estimates the effect of precipitation shocks at the ADM2 level on sales at the firm level while controlling for temperature and other firm-level controls. The following regression is estimated:

$$Y_{iagst} = \beta_1 Shock_{gt} + \gamma X_{it} + S_s + \alpha_a + \eta_t + \epsilon_{iagst} \quad (1)$$

Where: i indexes firms, a indexes sub-national ADM1 units, g indexes ADM2 units, s indexes sector (2 digit ISIC level) and t indexes survey-years. Note that ADM2 is more geographically disaggregated unit than ADM1. Y_{iagst} is the log of sales (in USD). $Shock_{st}$ represents measures of precipitation shocks. The main precipitation shock is number of dry days for a specific ADM2 unit. Average temperature is also accounted for in the estimations.

[2] In this way, our dry (wet) days measure is similar in to the `degree-days' temperature variables used in Schlenker and Roberts' well-known analysis of U.S. maize yields (Schlenker & Roberts, 2009).

We employ a small set of firm level control (X) in the estimation - whether the firm is a multi-firm, age of firm (in logs), size of firm (in logs), exporter status, foreign ownership, and whether the firm has a checking or savings account. Sector (ISIC 2 digit level) and survey year fixed effects are also included in the specification.

The main concern of the estimations are omitted variable bias and selection. The key identifying assumption in this analysis is that the experience of extreme dry days in a given year is quasi-random within a given ADM2 unit. A body of empirical climate change literature has exploited random variations in weather to estimate a reduced-form production function-style equation (Dell et al., 2012; Felbermayr et al., 2022; Kotz et al., 2022). Simultaneity bias is less of a concern given that individual firms are unlikely to influence precipitation shocks. To address omitted variable bias concerns, we control for a variety of controls at the firm-level. We also account for time-invariant omitted variables at the ADM1 geographical level through ADM1 fixed effects. Since the number of dry day shocks are exogenous, simultaneity bias is less of a concern. However, we cannot rule out the possibility that firm location selection is endogenous to precipitation shocks. If productive firms move to areas with fewer shocks, then it may appear as though shocks are negatively correlated with firm performance although it is driven to some extent by selection. We try to account for this concern by including controls for determinants of firm productivity. Also, given that our sample only consists of surviving firms, our estimates may understate the true effect if firms are driven out of business due to these negative shocks.

We explore potential channels through which precipitation shocks may affect sales. We achieve this by regressing various variables that have been identified in the literature as plausible channels of climatic shocks and other right-hand side variables defined in equation (1). Finally, a subsample of firms in the Middle East and North Africa, and Europe and Central Asia surveyed around the year 2019 were asked specific questions on green investments and adaptation. We exploit this data to evaluate if firms who experience precipitation shocks are more likely to adopt various green measures.

3. **Results**

3.1 Main Results

Table 2 provides the main results. An increase in dry days leads to a reduction in sales. The coefficient is statistically significant at the 5% level. In terms of magnitude, an additional extreme dry day leads to a 0.6 percent reduction in sales. The average no. of extreme dry days in the sample is 6.7 days such that an increase in extreme dry days of this amount translates to a 3.8 percent reduction in sales. A one standard deviation increase in extreme dry days (12.9 days) results in a 7.3 percent reduction in sales. Note that the average number of extreme dry days includes values of zeroes for areas that did not experience any extreme dry day. At the very extreme, the sample maximum for extreme dry days is 86 days, about 3 months. An increase of extreme dry days of around 3 months results in a 48.6 percent loss in sales. Given that we also find that extreme dry days lead firms to exit, these estimates reflect those of surviving firms and may, thus, underestimate the overall impact.

With regards to other covariates in the estimation, wet days are positively correlated with sales, statistically significant at the 1 percent level. This is consistent with Zaveri et al. (2023), who find that positive precipitation shocks can be a boon for the economy. The estimates for firm-level covariates are as expected: the size of the firm, age of the firm, foreign ownership, exporting firms and those that have access to checking accounts have more sales. All coefficients are statistically significant at the 1 percent level of significance.

Next, we explore heterogeneities in terms of level of development, region, firm size, and sector. These are reported in table 2. The results show that firms in developing economies are more vulnerable to extreme dry days than high-income economies. The coefficient of extreme dry days is negative and statistically significant for developing economies while for high-income economies the coefficient is statistically insignificant and almost half the size as that of developing economies in absolute terms. Firms in Latin America and the Caribbean are much more vulnerable to extreme dry days than other regions. It is the only region for which the coefficient of extreme dry days is negative and statistically significant, as well as the largest among all the regions in terms of magnitude. The coefficient of extreme dry days is negative for East Asia and the Pacific, Sub-Saharan Africa, and the Middle East and North Africa albeit statistically insignificant. Smaller firms, and firms in service sectors are also more vulnerable to extreme dry days than large firms and manufacturing firms.

3.2 Channels

We explore a number of channels highlighted in the literature through which negative precipitation shocks may affect firms. These largely include labor productivity, investment, infrastructure service interruptions (power and water outages), and access to finance. We also consider an additional channel not mentioned in the literature – corruption.

The main findings are presented in table 3. Extreme dry days lead to lower labor productivity, defined as sales per worker. This is consistent with Somanathan et al., (2021) that finds hot days lead to absenteeism and therefor lower labor productivity. While we do not see any effect of extreme hot days on full-time employment in the sample, the surveys do not capture absenteeism and health of the workers, and therefore we cannot rule out the possibility of these channels.

A prominent channel of the effects of extreme dry days is infrastructure. Extreme dry days lead to higher incidents of water and power outages, as well as larger losses due to electrical outages. This is consistent with the literature that have found that negative rainfall shocks lead to water outages (Hyland and Islam, 2019) and power outages (Desbureaux and Rodella, 2019). Note that extreme dry days do not only lead to power interruptions if hydropower is the source of energy. Water is needed for a variety of energy sources including nuclear energy. Furthermore, extreme dry days may increase the demand for energy, stressing the power infrastructure, and therefore leading to more power outages.

Extreme weather events can hurt the ability of firms to access finance. In table 3 we see that extreme dry days are negatively correlated with various access to finance indicators - bank financing of working capital, loan or line of credit, and existence of overdraft facilities. The coefficient of extreme dry days is only statistically significant for bank financing of working capital, and the presence of overdraft facilities. This is consistent with the negative relationship uncovered in the literature between extreme weather events and access to finance. Frequent climate shocks might affect the ability of banks to predict outcomes, and therefore increasing interest rates due to additional risk that results in increasing the cost of capital (Kling et al., 2021; Javadi and Masum, 2021; Brown et al., 2021). Extreme dry days could also lead to balance sheet erosion as firms that experience monetary losses from shocks become more leveraged as they are more likely to get their loan applications rejected and seen as less creditworthy (Benincasa et al., 2024). Weather shocks can also create liquidity shortages, increase loan defaults, deteriorating credit scores and thus access to future credit (Aguilar-Gomez et al., 2023). Similarly, Huang et al., (2018) find that extreme weather events are associated with lower and more volatile earnings and cash flows, resulting in exposed firms holding more cash to generate more financial slack and build resilience.

We also explore whether extreme weather days have any effects on investments by firms. The effect of extreme dry days on investment is ambiguous. If weather shocks limit access to finance, firms are less likely to invest. However, firms affected by weather shocks may also be more likely to invest in fixed assets as they replenish damaged capital (Benincasa et al., 2024). In table 3 we find that extreme dry days have no statistically significant relationship with whether a firm invests. However, when we break down investment in physical capital into (a) machine and equipment, and (b) land and buildings, we find different results. Extreme dry days have a positive and statistically significant effect on the likelihood that a firm will invest in land and buildings, consistent with Benincasa et al., (2024). However, there is no statistically significant relationship with whether a firm invests in machinery or equipment. This is a surprising finding. There are some potential explanations. One could be that extreme dry days have adverse effects on concrete, and thus firms may spend on renovating buildings (Wang et al., 2012). This is under the assumption that firms own the buildings they operate in. Another possibility is that supply chain disruptions due to extreme dry days may lead firms to increase storage due to increasing uncertainty. It may also be that exposure to extreme dry days leads firms to become more environmentally aware, and to invest in greener buildings. Unfortunately, the data does not provide information on the purpose of investment – whether for storage or renovations, or for more climate resilient buildings. There is also a possibility that since extreme dry days reduce access to finance, firms that would like to invest in greener fixed assets may prioritize buildings over machinery and equipment.

One surprising channel uncovered in the analysis is that firms are more likely to face bribes *to get things done* in locations exposed to extreme dry days. This may be explained by weakening economic conditions leading to more rent seeking behavior. Alternatively, it may mean that as a resource becomes scarce (in this case water), there may be greater incentives to solicit bribes.

3.3 Firm Exit

For countries with multiple waves of surveys, the status of firms surveyed in the initial wave is tracked in the succeeding wave. Therefore, we are able to tell if the firm is still in business or have exited the market. For about 23,000 firms that are tracked, there is an exit rate of about 26 percent. The findings in table 4 show that firms that are in locations that experience extreme dry days are more likely to exit the market. This implies that our estimates are largely based on surviving firms and therefore may be on the conservative side. The results in table 4 also show that there are no differential impacts of extreme dry days on firm exit by productivity of firm size. However, manufacturing firms in areas experiencing extreme dry days are less likely to exit while firms with a female top manager are more likely to exit. This provides some indication that women entrepreneurs may be vulnerable to extreme weather shocks.

3.4 Innovation, Digital Connectivity, and Exporters

In table 5 we explore whether innovation, digital connectivity and exporting status have any influence in the relationship between extreme dry days and sales. We find that firms that have innovated through improved processes, or have technology licensed from foreign firms tend to debilitate the effects of extreme dry days on sales. This may be explained by more innovative firms being more able to adapt to climate shocks, and therefore are more resilient. Sales of firms that are more likely to own a website are less affected by extreme dry days than firms that do not own a website. While the data does not allow us to explicitly explain this relationship, one could hypothesize that digital connectivity allows firms to access more information that could help them adapt to extreme dry days. Finally, exporters are found to be more resilient to shocks than non-exporters. This suggests that demand from abroad is not affected by localized extreme weather events, and that as long as firms adapt, they may be more likely to survive. This is in contrast to findings in the literature that suggest that exporters are also more likely to be affected than non-exporters (Huppertz, 2023).

3.5 Green Firms

The 2019 Enterprise Surveys wave for two regions - Eastern and Central Europe and Middle East and North Africa – has a special green module that captures whether firms adopt climate friendly measure (see table A1 for summary statistics). There is some evidence that firms exposed to extreme weather events are more likely to take steps to adapt by adopting climate-friendly measures (Benincasa et al., 2024). The destruction of physical capital due to extreme weather may result in new investments that lead to vintage effects where replenishment of capital means newer equipment with lower environmental footprint. Alternatively, firms may become environmentally aware and therefore engage in green investments or green management practices. Benincasa (2014) find that firms suffering losses from extreme weather display 12 percentage points greater likelihood of adopting climate-friendly measures. Firms exposed to extreme weather events are more likely to monitor their CO2 emissions. However, low-quality management practices and credit constraints can limit green investments (De Haas et al., 2021). The findings in table 6 show no statistically significant effect between extreme dry days and any of the green measures uncovered in the surveys. However, consistent with the main results of the overall sample, there is a negative effect of extreme dry days on sales and labor productivity – the magnitude is considerably larger than the main sample. Do note that one limitation of the green measures is that they ask whether firms have adopted new measures over the last three years. Thus, firms that may have adopted 4 years ago will be counted as though they have not adopted any measures.

3.6 Robustness – Sensitivity to Country Dominance

A concern is that a singly country in the sample may dominate the results. Figure 1 presents the coefficient estimates for extreme dry days as each country is dropped from the sample. Specifically, one country is dropped, the coefficient of extreme dry days is estimated. The country is then returned to the sample as another country is dropped. This process continues until at least every country has been dropped once. Since there are 118 countries in the sample, there are 118 coefficients reported in figure 1, including the 90 percent confidence intervals. As can be seen, the findings are robust to country dominance at the 90 percent level of significance.

4. Conclusion

This study uncovered a negative effect of extreme dry days on sales for a global sample of over 88,000 firms across 118 countries. The results reveal that the main channels are through a fall in labor productivity, increase in infrastructure service delivery interruptions, limited access to finance, and a greater exposure to bribery. Firms that are in locations facing extreme dry days are also more likely to exit. At the same time, firms that are innovative, digitally connected, and use foreign technology are more resilient to extreme dry days. However, evidence using a subset of firms for which data on green adoption exists, suggests that firms do not seem to respond to extreme dry days by being more environmentally aware or adopting efficient practices in terms of greening the economy.

Several policy recommendations emerge from the study. Climate shocks are an economy-wide concern, especially the intensity of negative precipitation shocks. Thus, labor that reallocates from rural to urban areas due to disruptions in the agriculture sector is still likely to face challenges in urban settings. Furthermore, exposure to shocks does not mean that firms adapt through green investments. Additional interventions may be needed for firms to internalize climate shocks. Finally, innovation and digital connectivity may be key to building resilience against shocks. Access to finance may especially be important, particularly for vulnerable small firms that face credit market failures.

The study has several limitations that future research may address. It is unable to unpack the labor related effects such as absenteeism and health. In addition, the universe of firms covered in this study are private formal firms with 5 or more employees. Therefore, the findings may be different for smaller informal firms on one hand, and large state-owned firms on the other end. The study is also unable to identify whether a reduction in sales is due to declining demand, or due to the inability of firms to supply goods. These are important avenues for future research to pursue.

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Table 1: Summary Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
Log of Sales (USD)	88,060	12.771	2.093	4.489	22.732
Log of Sales per Worker (USD)	87,541	10.066	1.699	0.797	18.978
Extreme Dry Days (Admin 2)	88,060	6.677	12.931	0	86
Extreme Water Days (Admin 2)	88,060	43.444	9.459	12	71
Average Temperature	88,060	18.357	7.141	-8.759	31.847
Average Temperature Squared	88,060	387.981	260.081	0.000003	1014.204
Firm is part of a larger firm Y/N	88,060	0.167	0.373	0	1
Log of age of firm	88,060	2.596	0.773	0	5.394
Log of size	88,060	2.775	1.097	-1.099	9.741
Direct exports 10% or more of sales Y/N	88,060	0.126	0.331	0	1
Foreign ownership Y/N	88,060	0.097	0.295	0	1
Establishment has checking or savings account Y/N	88,060	0.878	0.327	0	1
Firm purchased fixed assets Y/N	87,554	0.423	0.494	0	1
Firm Purchased Machinery and Equipment Y/N	85,120	0.392	0.488	0	1
Firm Purchased Land and Buildings Y/N	82,107	0.096	0.295	0	1
Website Y/N	87,904	0.512	0.500	0	1
Average No of Incidents of Water Shortages per Month (0 if no shortage, manf firms only)	44,887	0.891	6.414	0	365
Average No. of Power Outages per Month (0 if no shortage)	85,178	5.313	22.939	0	14000
Losses due to Electrical Outages (% of Annual Sales)	87,666	2.202	7.196	0	100
Establishment has a Line of Credit or Loan Y/N	86,690	0.354	0.478	0	1
Firm Use Banks to Finance Working Capital Y/N	86,077	0.299	0.458	0	1
Proportion of Working Capital Financed by Banks (%)	86,345	11.333	22.367	0	100
Establishment has Overdraft Facility Y/N	85,348	0.397	0.489	0	1
Firm Exit Y/N (conservative)	23,257	0.096	0.295	0	1
Firm Exit Y/N (extended)	23,257	0.259	0.438	0	1
Senior Management Time Spent in Dealing with Requirements of Government Regulations (%)	80,221	9.573	15.492	0	100
Firm Expected to Make a Payment to Get Things Done Y/N	80,282	0.173	0.378	0	1
Female Top Manager Y/N	87,910	0.177	0.382	0	1
Firm has a Female Owner Y/N	87,142	0.339	0.473	0	1
Manufacturing Sector Y/N	88,042	0.295	0.456	0	1
ISO Certification Ownership Y/N	86,093	0.164	0.370	0	1
Tech licensed from foreign firms Y/N	48,961	0.142	0.349	0	1
New/Significantly Improved Process Introduced over last 3 years	82,786	0.290	0.454	0	1
New Products/Services Introduced Over Last 3 years	83,978	0.348	0.476	0	1
Management Practices Quality	14,947	0.506	0.211	0	1
Experienced at least one bribe payment Y/N	58,019	0.178	0.382	0	1
Small and Medium Enterprise Y/N	88,060	0.925	0.264	0	1

Table 2: Precipitation Shocks and Sales

Model	**OLS with Admin 1 Fixed Effects**												
Dependent Variable	**Log of Sales (USD)**												
Sample	**Full Sample**	**Developing Economies**	**High Income Economies**	**East Asia and Pacific**	**Europe and Central Asia**	**Latin America and Caribbean**	**Middle East and North Africa**	**South Asia**	**Sub-Saharan Africa**	**Small and Medium Size Enterprises**	**Large Enterprises**	**Manufacturing**	**Services and Other Sectors**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
Extreme Dry Days (Admin 2)	-0.006**	-0.007**	0.004	-0.004	0.013	-0.012***	-0.002	0.007	-0.005	-0.007**	0.003	-0.003	-0.006*
	(0.003)	(0.003)	(0.010)	(0.009)	(0.008)	(0.004)	(0.015)	(0.011)	(0.006)	(0.003)	(0.005)	(0.003)	(0.003)
Extreme Water Days (Admin 2)	0.008***	0.009***	0.006	-0.002	0.008***	0.007	0.007	-0.010	0.003	0.009***	-0.006	0.003	0.011***
	(0.002)	(0.003)	(0.004)	(0.007)	(0.003)	(0.005)	(0.006)	(0.007)	(0.007)	(0.002)	(0.005)	(0.003)	(0.003)
Average Temperature	0.080**	0.112**	0.072	0.096	0.028	0.145	0.105	-0.377	-0.146	0.082**	0.094	0.059	0.097**
	(0.037)	(0.044)	(0.076)	(0.072)	(0.062)	(0.233)	(0.365)	(0.286)	(0.250)	(0.039)	(0.103)	(0.048)	(0.049)
Average Temperature Squared	-0.002	-0.002*	-0.003	-0.002	0.001	-0.003	-0.002	0.009	0.003	-0.002	-0.004	-0.002	-0.002
	(0.001)	(0.001)	(0.003)	(0.002)	(0.003)	(0.006)	(0.009)	(0.006)	(0.006)	(0.001)	(0.004)	(0.001)	(0.002)
Constant	8.070***	7.306***	10.106***	8.259***	9.290***	7.397***	7.738**	12.298***	9.763***	7.897***	9.932***	8.635***	7.825***
	(0.315)	(0.407)	(0.557)	(1.245)	(0.414)	(2.401)	(3.425)	(3.458)	(2.408)	(0.328)	(0.839)	(0.438)	(0.406)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Admin 1 Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sector (2 DIGIT ISIC) Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of observations	88,060	73,909	14,133	9,425	31,055	12,485	11,040	10,954	13,093	70,537	17,365	50,138	37,769
Adjusted R2	0.664	0.625	0.672	0.665	0.647	0.685	0.671	0.676	0.577	0.618	0.549	0.736	0.639

note: *** p<0.01, ** p<0.05, * p<0.1. Robust Standard Errors Clustered at the Size-Sector-Location strata. Main control variables include Extreme Water Days (Admin 2), Average Temperature, Firm is part of a larger firm Y/N, Log of age of firm, Log of size, Direct exports 10% or more of sales Y/N, Foreign ownership Y/N, Establishment has checking or savings account Y/N

Table 3: Channels

Model	OLS with Admin 1 Fixed Effects										
Dependent Variable	**Log of Sales per Worker (USD)**	**Average No of Incidents of Water Shortages per Month (0 if no shortage, manf firms only)**	**Average No. of Power Outages per Month (0 if no shortage)**	**Firm Purchased Fixed Assets Y/N**	**Firm Purchased Machinery and Equipment Y/N**	**Firm Purchased Land and Buildings Y/N**	**Losses due to Electrical Outages (% of Annual Sales)**	**Firm Use Banks to Finance Working Capital Y/N**	**Establishment has a Line of Credit or Loan Y/N**	**Establishment has Overdraft Facility Y/N**	**Firm Expected to Make a Payment to Get Things Done Y/N**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
Extreme Dry Days (Admin 2)	-0.005**	0.034***	0.076**	0.0003	-0.0004	0.003***	0.101***	-0.002*	-0.001	-0.003***	0.002***
	(0.003)	(0.013)	(0.030)	(0.001)	(0.001)	(0.000)	(0.016)	(0.001)	(0.001)	(0.001)	(0.001)
Extreme Water Days (Admin 2)	0.008***	0.021*	-0.006	-0.0004	0.0004	-0.001***	-0.007	0.001	0.001	0.002**	0.000
	(0.002)	(0.011)	(0.029)	(0.001)	(0.001)	(0.000)	(0.010)	(0.001)	(0.001)	(0.001)	(0.001)
Average Temperature	0.072*	-0.218	-0.177	0.003	0.007	0.001	-0.138	0.005	-0.014	-0.015	0.016
	(0.037)	(0.158)	(0.346)	(0.013)	(0.014)	(0.008)	(0.200)	(0.012)	(0.013)	(0.013)	(0.011)
Average Temperature Squared	-0.002	0.012*	0.011	-0.0001	-0.0002	-0.00002	0.013	0.00001	0.0004	0.0003	-0.001
	(0.001)	(0.007)	(0.014)	(0.000)	(0.000)	(0.000)	(0.009)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	8.163***	-1.213	3.353	0.171	0.077	0.004	-0.401	-0.096	0.102	0.064	0.006
	(0.315)	(0.755)	(2.414)	(0.130)	(0.132)	(0.073)	(1.055)	(0.114)	(0.124)	(0.115)	(0.096)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Admin 1 Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sector (2 DIGIT ISIC) Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of observations	87,541	44,808	85,171	87,553	85,114	82,104	87,666	86,074	86,688	85,347	80,274
Adjusted R2	0.490	0.149	0.299	0.186	0.189	0.122	0.291	0.172	0.219	0.324	0.259

note: *** p<0.01, ** p<0.05, * p<0.1. Robust Standard Errors Clustered at the Size-Sector-Location strata. Main control variables include Extreme Water Days (Admin 2), Average Temperature, Firm is part of a larger firm Y/N, Log of age of firm, Log of size, Direct exports 10% or more of sales Y/N, Foreign ownership Y/N, Establishment has checking or savings account Y/N

Table 4: Firm Exit

Model	OLS with Admin 1 Fixed Effects				
Dependent Variable	**Firm Exit Y/N**				
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**
Extreme Dry Days (Admin 2)	0.005**	0.005*	0.005**	0.005**	0.005**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Extreme Dry Days (Admin 2) X Labor Productivity		0.000005			
		(0.000)			
Labor Productivity (deflated, USD)		-0.011			
		(0.020)			
Extreme Dry Days (Admin 2) X Log of Size			-0.0002		
			(0.000)		
Extreme Dry Days (Admin 2) X Manufacturing				-0.002*	
				(0.001)	
Extreme Dry Days (Admin 2) X Female Top Manager					0.003*
					(0.002)
Female top manager Y/N					-0.108*
					(0.062)
Extreme Water Days (Admin 2)	-0.002	-0.002	-0.001	-0.001	-0.003
	(0.003)	(0.005)	(0.003)	(0.002)	(0.002)
Average Temperature	-0.016	-0.014	-0.016	-0.016	-0.015
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Average Temperature Squared	0.0005	0.0004	0.0005	0.0005	0.0005
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.592***	0.687***	0.568***	0.589***	0.606***
	(0.176)	(0.248)	(0.180)	(0.175)	(0.175)
Controls	YES	YES	YES	YES	YES
Admin 1 Fixed Effects	YES	YES	YES	YES	YES
Sector (2 DIGIT ISIC) Fixed Effects	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES
Number of observations	23,212	23,070	23,212	23,212	23,178
Adjusted R2	0.133	0.133	0.133	0.133	0.133

note: *** p<0.01, ** p<0.05, * p<0.1. Robust Standard Errors Clustered at the Size-Sector-Location strata. Main control variables include Extreme Water Days (Admin 2), Average Temperature, Firm is part of a larger firm Y/N, Log of age of firm, Log of size, Direct exports 10% or more of sales Y/N, Foreign ownership Y/N, Establishment has checking or savings account Y/N

Table 5: Innovation, Digital Connectivity, and Exporters

Model	OLS with Admin 1 Fixed Effects			
Dependent Variable	**Log of Sales (USD)**			
	coef/se	**coef/se**	**coef/se**	**coef/se**
Extreme Dry Days (Admin 2) X Website	0.004**			
	(0.002)			
Website Y/N	0.301***			
	(0.022)			
Extreme Dry Days (Admin 2) X Tech Licensed from Foreign Firms		0.008**		
		(0.004)		
Tech licensed from foreign firms Y/N		0.226***		
		(0.036)		
Extreme Dry Days (Admin 2) X Process Innovation			0.005***	
			(0.002)	
New/Significantly Improved Process Introduced over last 3 years			0.147***	
			(0.023)	
Extreme Dry Days (Admin 2) X Exporters				0.006**
				(0.003)
Extreme Dry Days (Admin 2)	-0.009***	-0.004	-0.003	-0.006**
	(0.003)	(0.003)	(0.003)	(0.003)
Extreme Water Days (Admin 2)	0.008***	0.002	0.006***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
Average Temperature	0.081**	0.055	0.073*	0.079**
	(0.037)	(0.048)	(0.038)	(0.037)
Average Temperature Squared	-0.002	-0.002	-0.001	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)
Direct exports 10% or more of sales Y/N	0.212***	0.250***	0.227***	0.212***
	(0.026)	(0.031)	(0.026)	(0.027)
Constant	8.061***	8.749***	8.072***	8.076***
	(0.312)	(0.428)	(0.313)	(0.315)
Controls	YES	YES	YES	YES
Admin 1 Fixed Effects	YES	YES	YES	YES
Sector (2 DIGIT ISIC) Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Number of observations	87,903	48,889	82,782	88,060
Adjusted R2	0.668	0.745	0.664	0.664

note: *** p<0.01, ** p<0.05, * p<0.1. Robust Standard Errors Clustered at the Size-Sector-Location strata. Main control variables include Extreme Water Days (Admin 2), Average Temperature, Firm is part of a larger firm Y/N, Log of age of firm, Log of size, Foreign ownership Y/N, Establishment has checking or savings account Y/N

Table 6: Green Practices and Precipitation Shocks (MENA ECA 2019 sample)

Model	**OLS with Admin 1 Fixed Effects**							
Dependent Variable	**Log of Sales (USD)**	**Log of Sales per Worker (USD)**	**Water Management Y/N**	**More Climate-Friendly Energy Generation On site Y/N**	**Machinery and Equipment Upgrades Y/N**	**Energy Management Y/N**	**Heating and Cooling Improveme nts Y/N**	**Adopt any Energy Efficiency Measures Y/N**
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
Extreme Dry Days (Admin 2)	-0.043**	-0.044**	-0.003	-0.004	-0.006	0.0004	0.005	0.004
	(0.021)	(0.021)	(0.004)	(0.004)	(0.006)	(0.009)	(0.009)	(0.006)
Extreme Water Days (Admin 2)	0.005	0.004	0.002	0.003*	-0.001	0.002	0.005**	0.0001
	(0.005)	(0.005)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Average Temperature	0.084	0.102	0.024	0.009	0.030	-0.024	-0.001	-0.035
	(0.073)	(0.074)	(0.029)	(0.023)	(0.032)	(0.029)	(0.031)	(0.029)
Average Temperature Squared	-0.002	-0.003	-0.001	-0.001	-0.001	0.001	-0.0002	0.001
	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	8.835***	8.877***	-0.264	-0.156	0.107	0.083	-0.113	0.303
	(0.561)	(0.564)	(0.200)	(0.174)	(0.247)	(0.221)	(0.245)	(0.224)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Admin 1 Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Sector (2 DIGIT ISIC) Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Number of observations	22,310	22,208	22,509	22,234	23,194	22,900	22,860	23,469
Adjusted R2	0.661	0.475	0.205	0.182	0.225	0.207	0.199	0.207

note: *** p<0.01, ** p<0.05, * p<0.1. Robust Standard Errors Clustered at the Size-Sector-Location strata. Main control variables include Extreme Water Days (Admin 2), Average Temperature, Firm is part of a larger firm Y/N, Log of age of firm, Log of size, Direct exports 10% or more of sales Y/N, Foreign ownership Y/N, Establishment has checking or savings account Y/N

Table A1: Summary Statistics MENA ECA Sample

Variable	Obs	Mean	Std. dev.	Min	Max
Log of Sales (USD)	22,310	13.013	1.783	5.439	20.456
Log of Sales per Worker (USD)	22,208	10.378	1.436	0.797	17.494
Extreme Dry Days (Admin 2)	22,310	0.294	1.311	0	18
Extreme Water Days (Admin 2)	22,310	44.530	7.133	15	66
Average Temperature	22,310	13.546	4.682	-1.394	26.869
Average Temperature Squared	22,310	205.405	123.655	0.000	721.934
Firm is part of a larger firm Y/N	22,310	0.090	0.286	0	1
Log of age of firm	22,310	2.681	0.718	0	5.268
Log of size	22,310	2.693	1.019	0	9.210
Direct exports 10% or more of sales Y/N	22,310	0.156	0.363	0	1
Foreign ownership Y/N	22,310	0.066	0.249	0	1
Establishment has checking or savings account Y/N	22,310	0.945	0.227	0	1
Water Management Y/N	20,494	0.163	0.369	0	1
More Climate-Friendly Energy Generation On site Y/N	20,232	0.107	0.309	0	1
Machinery and Equipment Upgrades Y/N	21,094	0.419	0.493	0	1
Energy Management Y/N	20,828	0.246	0.431	0	1
Heating and Cooling Improvements Y/N	20,770	0.342	0.474	0	1
Adopt any Energy Efficiency Measures Y/N	21,262	0.274	0.446	0	1

Table A2: Countries and Survey Years

Economy	Year	N	Economy	Year	N	Economy	Year	N	Economy	Year	N
Afghanistan	2014	111	Eswatini	2016	85	Malta	2019	171	Slovenia	2019	386
Albania	2013	279	Ethiopia	2011	421	Mauritania	2014	79	South Africa	2020	65
Albania	2019	317	Ethiopia	2015	726	Mexico	2010	1,293	South Sudan	2014	648
Argentina	2010	912	Finland	2020	644	Moldova	2013	299	Sudan	2014	235
Argentina	2017	799	Gambia, The	2018	97	Moldova	2019	346	Suriname	2018	148
Armenia	2013	236	Georgia	2013	273	Mongolia	2013	316	Sweden	2020	445
Armenia	2020	426	Georgia	2019	470	Mongolia	2019	351	Tajikistan	2013	243
Azerbaijan	2013	232	Ghana	2013	502	Montenegro	2013	86	Tajikistan	2019	245
Azerbaijan	2019	125	Greece	2018	528	Montenegro	2019	117	Tanzania	2013	371
Bangladesh	2013	1,350	Guatemala	2010	352	Morocco	2013	179	Thailand	2016	760
Belarus	2013	281	Guatemala	2017	238	Morocco	2019	345	Timor-Leste	2015	69
Belarus	2018	561	Guinea	2016	45	Mozambique	2018	500	Togo	2016	115
Belgium	2020	565	Honduras	2010	249	Myanmar	2014	500	Tunisia	2013	485
Benin	2016	102	Honduras	2016	237	Myanmar	2016	559	Tunisia	2020	459
Bolivia	2010	39	Hungary	2013	180	Namibia	2014	268	Türkiye	2013	709
Bolivia	2017	96	Hungary	2019	772	Nepal	2013	469	Türkiye	2019	1,436
Bosnia and Herzegovina	2013	292	India	2014	8,685	Netherlands	2020	750	Uganda	2013	443
Bosnia and Herzegovina	2019	306	Indonesia	2015	1,177	Nicaragua	2010	261	Ukraine	2013	695
Bulgaria	2013	260	Iraq	2011	735	Nicaragua	2016	285	Ukraine	2019	1,095
Bulgaria	2019	617	Ireland	2020	269	Niger	2017	102	Uruguay	2010	381
Burundi	2014	143	Israel	2013	399	Nigeria	2014	1,681	Uruguay	2017	217
Cambodia	2016	294	Italy	2019	656	North Macedonia	2013	325	Uzbekistan	2013	361
Cameroon	2016	162	Jordan	2013	518	North Macedonia	2019	295	Uzbekistan	2019	1,063
Central African Republic	2011	131	Jordan	2019	312	Pakistan	2013	340	Venezuela, RB	2010	185
Chad	2018	141	Kazakhstan	2013	414	Panama	2010	12	Viet Nam	2015	862
Chile	2010	816	Kazakhstan	2019	1,098	Papua New Guinea	2015	46	West Bank and Gaza	2013	377
China	2012	2,159	Kenya	2013	600	Paraguay	2010	307	West Bank and Gaza	2019	305
Colombia	2010	887	Kenya	2018	827	Paraguay	2017	308	Yemen, Rep.	2010	267
Colombia	2017	892	Kosovo	2013	174	Peru	2010	785	Yemen, Rep.	2013	244
Costa Rica	2010	412	Kosovo	2019	162	Peru	2017	678	Zambia	2013	606
Croatia	2013	282	Kyrgyz Republic	2013	209	Philippines	2015	1,004	Zambia	2019	548
Croatia	2019	368	Kyrgyz Republic	2019	313	Poland	2013	370	Zimbabwe	2011	558
Cyprus	2019	172	Lao PDR	2016	344	Poland	2019	688	Zimbabwe	2016	565
Czechia	2013	207	Lao PDR	2018	283	Portugal	2019	787			
Czechia	2019	482	Latvia	2013	243	Romania	2013	457			
Djibouti	2013	106	Latvia	2019	291	Romania	2019	780			
Dominican Republic	2016	198	Lebanon	2013	275	Russian Federation	2012	2,822			
Congo, Dem. Rep.	2013	422	Lebanon	2019	352	Russian Federation	2019	1,111			
Ecuador	2010	314	Lesotho	2016	126	Rwanda	2011	189			
Ecuador	2017	333	Liberia	2017	126	Rwanda	2019	355			
Egypt, Arab Rep.	2013	1,345	Lithuania	2013	203	Senegal	2014	305			
Egypt, Arab Rep.	2016	1,374	Lithuania	2019	342	Serbia	2013	327			
Egypt, Arab Rep.	2020	2,795	Luxembourg	2020	158	Serbia	2019	292			
El Salvador	2010	281	Madagascar	2013	227	Sierra Leone	2017	115			
El Salvador	2016	570	Malawi	2014	310	Slovak Republic	2013	168			

Estonia	2013	128	Malaysia	2015	702	Slovak Republic	2019	417
Estonia	2019	177	Mali	2016	153	Slovenia	2013	230

Figure 1: Sensitivity Country Dominance