When the Temperature Drops, Perceptions Worsen: Effects of Extreme Cold on Perceptions of Government and Civic Participation in the Peruvian Highlands*

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Abstract

We examine how extreme weather affects individuals' perceptions of government and political institutions in Peru. We match granular data on cold weather shocks to individuals using variation in interview date and location and find that extreme cold worsens perceptions of democracy. Further, extreme cold reduces civic engagement in formal democratic institutions (participation in national elections) but increases participation in local neighborhood associations. We provide evidence that these effects work through several mechanisms: economic losses, increased incidence of illness, and higher crimes. Finally, we find that greater coverage of government-provided goods and services can attenuate the adverse effects of extreme cold.

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1 Introduction

A growing body of empirical evidence illustrates the role of trust and confidence in government in determining a myriad of important political economy outcomes, such as policy preferences (Fairbrother, 2019; Marien and Hooghe, 2011), compliance with laws (Citrin and Stoker, 2018), political participation (Grönlund and Setälä, 2007; Bélanger and Nadeau, 2005; Bélanger, 2017), voting behavior (Dalton and Weldon, 2005; Citrin and Stoker, 2018; Guiso et al., 2020; Bélanger, 2017), and the use of public goods and services (Christensen et al., 2021; Alsan and Wanamaker, 2018; Lowes and Montero, 2021; Martinez-Bravo and Stegmann, 2022; León-Ciliotta et al., 2022). However, less is known about what determines sentiments towards government and political systems at the individual level.

Exposure to extreme weather can have devastating effects on livelihoods – for example, on economic standing (Dell et al., 2012; Skoufias et al., 2012; Zhang et al., 2017; Schlenker et al., 2009; Aragón et al., 2021); health (Deschenes and Moretti, 2009; Deschênes and Greenstone, 2011); and crime (Simister and Cooper, 2005; Simister, 2001; Miguel, 2005; Ranson, 2014; Iyer and Topalova, 2014; Blakeslee and Fishman, 2013). Thus, bouts of extreme weather can test government capacity and efficacy. Intuitively, weather-related adverse shocks may "shine a light" on the government's ability to address citizens' needs, and in turn, may worsen perceptions of government and democracy, particularly where government programs and services are insufficient.

In this paper, we study the effect of extreme cold on individuals' beliefs about how well democracy functions in Peru. This outcome captures an overall perception of the way democracy functions, both in terms of "diffuse" attitudes toward the political system (i.e., democracy as a regime) and "specific" satisfaction with or confidence in government in practice (i.e., citizens' evaluation of the performance of government bodies).[1] Peru is an ideal context for studying this relationship for several reasons. Peru has some of the lowest levels of political trust in Latin America (see Appendix Figure A1) and a history of political instability, suggesting that it is a setting in which perceptions of government are especially important. Peru is also one of the most vulnerable countries to climate change worldwide (Stern, 2007; Tambet and Stopnitzky, 2021). Frost and cold

[1] We discuss the interpretation of this variable in more detail in Section 3.1.

waves have become increasingly common and devastating, highlighting the region's vulnerability to weather volatility (Painter, 2008; Tambet and Stopnitzky, 2021; Keller and Echeverría, 2013; FAO, 2008).

We first show that extreme cold significantly reduces positive perceptions of democracy. We do so by matching households in the 2007-2018 rounds of the Peruvian National Household Survey (ENAHO) to hourly temperature data from the European Centre for Medium-Range Weather Forecasts (ECMWF). Matching is based on households' GPS locations and dates of interview.[2] Our primary measure of extreme cold is the cumulative degree hours (CDH) that a household has experienced below a given temperature threshold in the 12 months leading up to the survey (when perceptions are elicited). This measure captures both the duration of cold experienced below a specific threshold and the extent to which temperatures fell below that threshold. Conditional on spatial and temporal fixed effects, an additional ten hours below the threshold of -9°Celsius over the previous year reduces the probability that an individual believes that democracy functions well by 0.38 percentage points. Our results are robust to a battery of robustness checks, including varying temperature thresholds and measures of extreme cold, using alternate data sources on perceptions of government, accounting for potential endogenous migration, and falsification exercises using future weather shocks.

We explain this relationship by analyzing three key mechanisms: economic losses, increased health risks, and higher exposure to crimes. 10 additional degree-hours below the threshold of -9°C in the past year reduces agricultural revenue by 1.4% and economic losses due to livestock deaths by 2.5%. Extreme cold also worsens health outcomes, particularly for vulnerable populations: 10-degree hours below -9°C increases the probability that young children and elderly household members require medical attention by 0.6 percentage points and are hospitalized by 0.3 percentage points. Finally, cold shocks increase crime, especially economic crimes (e.g., burglary, theft, fraud, and sales of illicit goods). 10 CDH below -9°C increases economic crimes per capita by 2.0% and overall crime by 1.2%.

To demonstrate the importance of these findings, we show that cold shocks influence critical

[2]Household location is specific to the village centroid in rural areas and the neighborhood block in urban areas.

downstream outcomes, namely voting and participation in local associations. As cold shocks erode positive perceptions of government, we find that individuals become less likely to vote in national elections, consistent with previous evidence that political mistrust discourages voting (Bélanger, 2017). The share of absent voters is significantly higher in districts that experience cold weather shocks. These results are particularly salient in the context of Peru, where very narrow margins often decide the outcomes of national elections. This reduction in electoral participation suggests that extreme cold may be especially important for lowering confidence in the overall system of democracy, as opposed to a reduction in the support for the incumbent party (which may increase votes for challenging parties but is less likely to decrease overall voting). In contrast, extreme cold increases engagement in local institutions, especially in community-based associations.[3] Taken together, these two findings are consistent with negative shocks inducing citizens to turn away from formal national institutions in favor of less formal and more local institutions.

Finally, we show that public provision of goods and services can mitigate the effects of extreme cold on perceptions of government. We construct a composite indicator of baseline public goods and services provision using three measures relevant to the mechanisms we study: social program coverage, public health facilities, and police resources. In provinces that have historically lower access to public goods and services (at baseline), the effects of a cold weather shock on perceptions of government and voting absenteeism are large and significant. In contrast, the effects are much smaller in areas with a higher coverage of public goods and services, though the differences are not always statistically significant.[4]

Our research makes important strides in understanding both the causes and consequences of citizens' perceptions of democracy and government. Economic evidence on the determinants of confidence and trust in government is scarce, and thus far, limited to the effects of exposure to violence, crime, and conflict (Blanco and Ruiz, 2013; Blanco, 2013; Malásquez and Salgado, 2023; Stevenson and Wolfers, 2011).[5] We are the first to demonstrate that extreme weather

[3]These results complement recent work by Buggle and Durante (2021), who find that historical climate variability fostered interpersonal trust in Europe with lasting impacts on norms and institutions.

[4]These findings are consistent with prior work that shows that public policy can attenuate the negative consequences of weather shocks on conflict and violence (Fetzer, 2014; Sarsons, 2015; Garg et al., 2020).

[5]Outside of economics, some papers examine the roots of government perceptions, though the evidence is heavily skewed toward rich economies and/or often correlational in nature (Citrin and Stoker, 2018; Zmerli and Van der Meer,

— specifically, extreme cold — is one important factor shaping citizens' broad perceptions of government.[6] We go beyond existing studies and explore both the pathways through which adverse weather-related shocks impact perceptions of democracy and government and the extent to which government provision of goods and services mitigates the impact of negative shocks. Furthermore, we demonstrate the importance of perceptions in key, tangible outcomes, and highlight that extreme cold lowers participation in national elections. Our results suggest that as extreme weather events become more frequent and severe, climate change may have implications for fundamental government institutions.

Our results also complement the extensive body of work linking extreme weather to conflict and political instability (for example, Miguel et al., 2004; Burke et al., 2009; Dell et al., 2012; Hsiang et al., 2011; Harari and La Ferrara, 2018; Ranson, 2014; Maystadt and Ecker, 2014; Sarsons, 2015; Hsiang et al., 2013).[7] Specifically, we show that weather shocks erode political trust and participation in formal political systems and thus could act as potential precursors to conflict and violence (Engvall, 2010; Buhaug, 2010).

Finally, we build on the previous literature evaluating the effects of extreme weather by focusing on a novel measure: extreme cold. Though the adverse effects of floods, droughts, and extreme heat have been documented on an array of outcomes, to our knowledge, we are the first to establish the effects of extreme cold on economic and political outcomes in a developing country. Though average temperatures are expected to rise globally with climate change, there is evidence that extreme cold events may also become more common (Cai et al., 2015; Geng et al., 2023; Cohen et al., 2018; Kim et al., 2017).[8]

2017; Rhein and Jansesberger, 2024).

[6]By focusing on a measure of broad perceptions of democracy and government functioning, our paper differs from those who study the effects of natural disasters and other weather events on support for a specific political actor or incumbent party (for example, Ahlerup et al. (2023); Balcazar and Kennard (2023)). This distinction appears to be important, as our results on voter participation are consistent with a decline in diffuse support for democracy and government, rather than specific support for a particular party or actor.

[7]While the research relating climate change and conflict is relatively recent, evidence suggests that weather has affected governance and political stability throughout human history. A growing strand of the literature analyzes long-term historical consequences of changes in climatic patterns on conflict in ancient civilizations (Chaney, 2013; Kung and Ma, 2014; Jia, 2014; Yancheva et al., 2007).

[8]In the northern hemisphere, this is attributed to the polar vortex or the "accelerated Arctic warming", which has induced more severe cold-air outbreaks in North America and Eurasia (Cohen et al., 2018; Kim et al., 2017). In the southern hemisphere, the recent surge in extreme cold events is attributed to episodes of La Niña, which are projected to increase in both frequency and duration (Cai et al., 2015; Geng et al., 2023).

2 Background

2.1 Political background

Formally, Peru is a democracy in which the president and members of Congress are elected by popular vote every five years. However, its political system has been plagued by corrupt leaders and unstable environments in the last three decades; The Economist Intelligence Unit (2023) classifies Peru as a *hybrid regime*, somewhere between a "flawed democracy" and an "authoritarian regime". Political parties collapsed in the 1990s — a phenomenon that Tanaka (2005) describes as having left Peru as a "party-less democracy" — and have remained weak. Since 2016, tensions between the executive and legislative branches of government have escalated: Congress has impeached three presidents, one president dissolved Congress, and another staged a failed *coup d'état*.

Furthermore, Peruvian politics have been deeply entrenched in systemic corruption. Every elected president since 1985 has either faced jail time for corruption or has had credible corruption allegations against them (Bristow, 2022). Other branches of government are similarly perceived as corrupt; members of Congress and the National Board of Justice (a council that appoints and removes judges from office) have also faced corruption charges (Wall Street Journal, 2020; IDEHPUCP, 2020; La República, 2021).

These governance problems have translated into a relatively poor provision of public services in Peru. For example, in theory, the government provides universal access to health services in public facilities. However, in practice, the inadequate provision of these services excludes a large share of the population from proper healthcare: Aguirre Martens (2023) estimates that seven out of ten people who needed medical care did not receive it. Among this group, the main reasons for not receiving attention were long waiting times (35%) or distrust of staff (14%). Unsurprinsingly, another barrier to accessing medical care is the high cost; Díaz Ruiz et al. (2024) find that those who are able get medical consultations tend to be the wealthiest. Public safety services face an analogous situation: in 2011, nearly half (47.3%) of districts in Peru had no police station.[9] Moreover, trust in police forces is low; only 26% of Peruvians perceive that the police act lawfully (World Justice

[9] Authors' calculations using the 2011 CENACOM (Instituto Nacional de Estadística e Informática, 2012).

Project, 2023). In 2005, the government launched a conditional cash transfer program (Juntos), which provides poor families in Peru with a monthly subsidy of 100 soles (about US$26). Juntos has had many positive effects on outcomes such as early nutritional status and school attendance (see Sánchez and Rodríguez 2016 for a synthesis of effects). However, the nominal subsidy amount has remained unchanged since 2010. During the early years of the program, the Juntos transfer represented approximately 10% of beneficiary households' consumption on average (Scott et al., 2022). However, inflation has eroded the real value of this transfer and its capacity to effectively aid the poorest households.

Thus, it is not surprising that Peru is one of the countries with the lowest levels political trust in Latin America. Appendix Figure A1 shows that, in a sample of 17 Latin American countries, Peruvians' trust in democratic institutions (i.e., the national congress, political parties, and the government) is the second-lowest, surpassing only Ecuador. Furthermore, only half of Peruvians believe that democracy is better than alternatives systems of government (Appendix Figure A2).

Presidential elections typically include two rounds. All parties compete in the first round. If no party wins more than 50% of the votes in the first round, the top two parties from the first round compete in a run-off. Voting is mandatory for all citizens aged 18–70. Those who do not cast a vote face a fine that ranges from approximately US$6 (in poorer districts) to approximately US$25 (in wealthier districts). Because of these penalties, turnout is generally high but not universal; in 2011, turnout in the second round of the generation was 82.5% (European Union Election Observation Mission, 2011).

2.2 Extreme cold in the Peruvian highlands

In this paper, we focus on the rural highlands of Peru, where extreme cold events are most common. The highlands are a region that has been left behind despite Peru's considerable and sustained economic growth in the last two decades, a period over which GDP per capita doubled nationally. By 2018, 13.1% of the population in Metropolitan Lima (the Peruvian capital) was poor. In contrast, the poverty rate in the rural highlands was 49% (INEI, 2019). Compounding this vulnerable situation, the rural highlands are also subject to considerable weather shocks (e.g., droughts, floods, frosts, cold waves, etc.; World Bank 2008). Most experts argue that this situation will continue to worsen in the future, as Peru is one of the most vulnerable countries to climate change (Stern, 2007; Tambet and Stopnitzky, 2021). Frosts and extreme cold events have become increasingly common in Peru over the last two decades, affecting millions of Peruvians (Keller and Echeverría, 2013; FAO, 2008), particularly those in the highlands, which are located at elevated altitudes (between 500 and 6,798 meters above sea level). In recent years, extreme cold temperatures have dipped as low as -20°C in some areas, affecting close to 200 thousand inhabitants (Centre for Research on the Epidemiology of Disasters, 2023).

Extreme cold can have particularly severe consequences on agricultural output, an essential economic activity in the highlands. The extent of crop damage induced by frosts depends on the intensity of the frost (i.e., the duration of cold and how low the temperature drops), the frequency of these events, the type of crops, and the phenological state of the plants (Snyder and Melo-Abreu, 2005). Crop loss can be extreme; for example, a frost in 2008 destroyed 45% of potato production in several high-altitude Peruvian provinces (FAO, 2008).[10] Extreme cold can also have detrimental effects on livestock by depleting food sources and directly resulting in hypothermia and frostbite. Livestock are valuable assets for rural households in the Peruvian Andes (Kristjanson et al., 2007), serving as sources of food, energy, fertilizer, transport, income from sales of fiber, and buffer stocks that can be sold in times of need (León-Velarde and Quiroz, 2003; Herrero et al., 2013). In 2015, temperatures in the state of Puno reached -20°C, killing 170 thousand alpacas, one of the most important types of livestock in the Peruvian highlands (BBC News, 2015). Thus, the continued threat of frosts is a concern for much of the highlands. CENEPRED (2021) estimates that there are 823 districts (encompassing around 1 million farmers and 3.3 million hectares of agricultural land) under high or very high risk of experiencing frosts.

In addition to its negative impact on farm income, extreme cold weather can also have severe health consequences, especially for vulnerable groups such as the very young and the elderly (Centers for Disease Control and Prevention, 2024; Deschenes and Moretti, 2009). Cold weather is significantly associated with the incidence of respiratory tract infections (Zhao et al., 2021; Kephart

[10] Frost damage in agriculture is not limited to Peru. A 2021 frost caused an estimated US$ 1 billion losses to coffee farmers in the Brazilian state of Minas Gerais (Samora, 2021). During the same year, another frost generated around € 2 billion in losses in French wine production (The Guardian, 2021).

et al., 2022; Sheridan and Allen, 2015). In 2010, extreme cold temperatures related to a *La Niña* event killed 250 children (mostly under the age of five) in Peru due to "cold-related respiratory diseases, mostly pneumonia" (Kirkland, 2012).

Less is known about whether extreme cold affects crime and violence, though previous studies have found that *hotter* temperatures can increase both (Blakeslee and Fishman, 2018; Mukherjee and Sanders, 2021; Colmer and Doleac, 2022; Mares and Moffett, 2019; Garg et al., 2020; Simister, 2001; Simister and Cooper, 2005). Much of this literature finds that income losses and physiological responses to heat are mechanisms, which suggests that extreme cold may also increase crime and violence through similar pathways. Indeed, in a companion paper, we find that cold events increase a specific form of violence: intimate partner abuse (Bollman et al., 2024).

All in all, the Peruvian highlands are vulnerable to frosts that can have negative impacts on agricultural production, income, productive assets (such as livestock), health outcomes, and crime. We hypothesize that such shocks can translate into political mistrust in a country that has faced long-standing governance crises.

3 Data and Variables

Our analysis uses two main data sources: the Peruvian National Household Survey (*Encuesta Nacional de Hogares* - ENAHO) and weather data from the European Centre for Medium-Range Weather Forecasts (ECMWF). In this section, we describe these datasets, our main estimation sample, and the auxiliary data used in our robustness checks and mechanism analysis.

3.1 Encuesta Nacional de Hogares (ENAHO)

The ENAHO is a cross-sectional household survey collected annually by the National Statistics Office (Instituto Nacional de Estadística e Informática 2018b - INEI). We use twelve rounds of the ENAHO (2007-2018) and focus on several dimensions of the survey. The first is a module on individuals' perceptions of governance. Only one randomly chosen adult (18 years or older) in each household is sampled for this module.

Our primary outcome variable measures whether citizens believe that democracy works well in Peru. Specifically, we focus on a question that asks the following: "In Peru, does democracy work..?" and gives respondents the following response options": "very well", "well", "poorly", and "very poorly". We define an indicator variable that takes the value of one for those who believe democracy works "well" or "very well" and zero otherwise.[11]

$$Y_{idt} = \begin{cases} 1 & \text{if response is "very well" or "well"} \\ 0 & \text{if response is "very poorly" or "poorly"} \end{cases} \tag{1}$$

We believe that this variable represents an overall perception of the way democracy functions in Peru, both in terms of so-called "diffuse" attitudes towards the political system (i.e., democracy as a principle or as a broad institution) and "specific" satisfaction with or confidence in the current government regimes (i.e., how democracy works in practice and citizens' evaluation of the performance of government bodies). We find empirical support for both interpretations of this measure. Table 1 displays conditional correlations between our primary outcome measure (the belief that democracy works well in Peru) and a battery of other measures of political trust and confidence in specific institutions.[12] We find that the belief democracy works well is most highly correlated with evaluations of how well different levels of government (central, regional, provincial, and district) are managed. It is also correlated with confidence in specific government bodies, such as the national Congress, the Judiciary, and Political parties. However, it also reflects more general beliefs about democracy as a system: it is highly correlated with the belief that democracy is always the most preferred form of government and that democracy is important.

In this way, we see our outcome as being comparable to the widely used "satisfaction with democracy" (SWD) measure. SWD is typically elicited with very similar questions, such as: "On the whole, are you very satisfied, fairly satisfied, not very satisfied, or not at all satisfied with the way democracy works in [country]?" SWD has largely been interpreted as a combined measure of support for both broad democratic principles and specific government bodies or current leaders (Kölln and Aarts, 2021; Clarke et al., 1993; Christmann, 2018; Kosec and Mo, 2023).

[11] The questionnaire also includes an option for "do not know", which is chosen by about 24% of individuals. In our main analysis, we drop these observations from our sample; in Section 5.1, we show that our results are robust including these observations as a neutral, middle category.

[12] The coefficients in Table 1 are from separate regressions representing the association between citizens' beliefs that democracy works well in Peru and citizens' support for government bodies and confidence in institutions. All regressions include district, year, and month-of-interview fixed effects.

Table 1: Correlates of Perceptions of Democracy

	Dep. Variable: Believes Democracy Works Well in Peru
Supports Management of Central Govt†	0.235***
	(0.006)
Supports Management of Regional Govt†	0.224***
	(0.007)
Supports Management of Provincial Govt†	0.225***
	(0.006)
Believes Democracy is Important	0.223***
	(0.006)
Supports Management of District Govt†	0.211***
	(0.006)
Confidence in Political Parties	0.140***
	(0.007)
Confidence in Congress	0.129***
	(0.005)
Confidence in Regional Government	0.119***
	(0.005)
Confidence in Municipal Government	0.116***
	(0.005)
Confidence in Provincial Government	0.106***
	(0.005)
Confidence in the Judiciary	0.110***
	(0.005)
Believes Democracy is Preferable	0.102***
	(0.006)
Confidence in Police	0.101***
	(0.005)
Confidence in Armed Forces	0.050***
	(0.005)

Note: Each coefficient comes from a separate regression with district, year, and month-of-interview fixed effects and "Believes Democracy Works Well" as the dependent variable. The sample in the regressions includes the 2007-2018 rounds of ENAHO. † However, due to lack of data availability, the top four variables (management of the central, regional, provincial, and district governments) are only analyzed for the 2012-2018 rounds of the ENAHO. District-level clustered standard errors in parentheses. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

We also use the ENAHO to complile an array of other information about households, including demographics (e.g., age, sex, and education of household members), health status of children aged 5 years and under and individuals 65 and over, agricultural revenue and total income, participation in social programs, and membership in local associations. Importantly, the INEI also provides detailed information about households' location: in rural areas, the ENAHO reports GPS coordinates for the village where the household lives, and in urban areas, it reports coordinates for the centroid of the neighborhood block.

3.2 Weather Data

We collect detailed hourly temperatures for each day between 2010 and 2019 from the ERA5 of the European Centre for Medium-Range Weather Forecasts (2018) (ECMWF). The ECMWF estimates temperatures from weather stations, satellites, and sondes, and processes this information at a geographic resolution of 0.25 degrees (31 km).[13] We match household data from the ENAHO with the ECMWF weather data using households' location and month and year of interview. This allows us to construct a household-specific measure of extreme cold exposure throughout the year prior to interview (the standard recall period for most survey questions).

As described in Bollman et al. (2024), we build on the widely used cumulative degree days measure from Schlenker and Roberts (2006) and estimate the number of cumulative degree *hours* in which a household experienced extreme cold temperatures. This measure captures both the duration and the severity of extreme cold events — i.e., for how long and by how much a household experienced temperatures below a certain threshold. Denote the temperature threshold λ, where λ= 0°C, -1°C, -2°C,... , -12°C. We begin by defining harmful degree hours (DH) as the extent (in °C) to which a given hour's temperature falls below the threshold λ:

$$\text{Degree Hours}(\text{DH}_{itmdh}) = \begin{cases} \lambda - h_{itmdh} & \text{if } h_{itmdh} < \lambda \\ 0 & h_{itmdh} \geq \lambda \end{cases} \tag{2}$$

where h_{itmd} is the temperature in household i's location, on year t, month m, and hour h of day d.

[13] In terms of area, this is approximately equivalent to the average district size in Peru.

For example, if λ=-1°C, an hour of temperature at -3°C represents 2 degree hours. Based on the agronomic literature, we choose a baseline threshold of -9°C, a temperature that is harmful for many crops grown in the highlands (Lee and Herbek, 2012; Carter and Hesterman, 1990; Hijmans et al., 2001; Burrows, 2019; Janssen, 2004; Romero et al., 1989). However, as sensitivity to cold can vary across crops, we show our results using a wide range of temperature thresholds (from 0°C to -12°C).

Our primary measure of extreme cold exposure is the *cumulative* degree hours (CDH) below threshold λ that household i interviewed in month m and year t experienced over the 12 months prior to the survey. In other words, we aggregate DH over the hours in the year prior to the interview date.[14]

$$\text{Cumulative Degree Hours}(\text{CDH}_{it}) = \sum_{m=-12}^{-1} \sum_{d=1}^{30} \sum_{h=1}^{24} \text{DH}_{itmdh} \tag{3}$$

Additionally, we extract rainfall data from the Weather Hazards Group InfraRed Precipitation with Station Data, CHIRPS (Funk, 2015). CHIRPS is a global dataset that provides high-resolution estimates of rainfall for 0.05 X 0.05 degree pixels. We match rainfall to households using GPS coordinates and interview dates from the ENAHO using the same procedure as we use for the temperature data.

3.3 Main Estimation Sample

Due to the nature and geographic scope of cold weather shocks in Peru, we restrict our sample to farming households in the highlands.[15] With these restrictions, we obtain a sample of 57,159 households across 938 districts in the Peruvian highlands.[16] Table 2 presents the summary statistics for our sample.

About 63% of the sample has completed at most primary school and over half of the sample

[14] We choose this time frame for our baseline CDH calculations to match the reference period for all income variables, one of the primary mechanisms we study. In Section 5.1, we show that our results are robust to using other windows. In some regressions, we use a shorter window of time to calculate CDH in order to match the reference period for the outcome variable of interest (e.g., morbidity outcomes have a recall period of 4 weeks instead of 12 months).

[15] Appendix Figure A3a shows that farming households the Highlands (surveyed in the ENAHO between 2007-2018) are located precisely in the regions of Peru that are more susceptible to experiencing frosts (Appendix Figure A3b).

[16] There are 1,873 districts in Peru, so our sample covers around half of all districts in the country.

Table 2: Descriptive Statistics

	Full Sample (1)	Households Facing Frost Shocks (2)	Households Not Facing Frost Shocks (3)
Believes Democracy Works Well	.511	.487	.512
Weather Variables			
CDH (λ = -9°C)	.755	14.981	0
Average Temperature	9.542	5.318	9.766
Average Rainfall	65.303	65.314	65.302
Mechanisms			
Total Agricultural Revenue	3039.5	1696.8	3110.7
Value of Livestock Losses	751.6	242.2	781.3
Individual Required Medical Attention	.302	.329	.302
Individual Was Hospitalized	.034	.026	.034
Individual and Household Characteristics			
Male	.509	.498	.51
Age	46.724	47.632	46.676
Household Size	4.014	3.88	4.021
Education			
Primary or Less	.628	.626	.628
Secondary	.285	.286	.285
Technical	.05	.057	.049
College	.037	.032	.038
Mother Tongue			
Quechua	.518	.830	.501
Spanish	.428	.096	.445
Amarya or Other Indig.	.055	.075	.054
Observations	57159	2880	54279

Notes: All monetary variables are expressed in 2007 soles using the GDP deflator published by World Bank (2023). The main sample (column 1) includes individuals in all farming households in the Highlands in the ENAHO 2007-2018 . We further split the sample into households that have experienced frost shocks during the 12 months before their interview date based on a threshold of $\lambda = -9$°C (column 2) and those that have not (column 3). The sample for health variables is further restricted to individuals aged 5 and under and 65 and over living in the main sample households. For these variables, the reference period used to split the sample into facing and not facing frost shocks is 8 weeks (see Section 5.2).

speaks Quechua (the most prominent indigenous language in Peru) at home (column 1). Though the average household has experienced less than one harmful degree hour at the threshold of -9°Celsius, this is because only 5% of households experience temperatures below this threshold (Appendix Figure A4). Conditional on having been exposed to temperatures below this threshold, the average CDH in the sample is about 15.

Only about half of the individuals in our full sample believe that democracy works well in Peru. When we break down the sample into households that face and do not face frost shocks (columns 2 and 3), we see that those who face frost shocks are about 1.2 percentage points less likely to report that democracy works well. Households facing frost shocks also tend to have lower agricultural and total income, and they are more likely to have household members that have required medical attention or hospitalization. In terms of predetermined individual and household characteristics, households that have and have not faced frost shocks are largely similar, with the exception that those facing frost shocks are more likely to speak Quechua as their mother tongue.

3.4 Other Data Sources

Organismo Nacional de Procesos Electorales (ONPE). We obtain data on voting outcomes at the district level from the Peruvian National Elections Commission (2016). We focus on the 2011 and 2016 Peruvian presidential elections, the two presidential elections that occurred during our sample period. Presidential elections in Peru proceed in two rounds. In the first round, several candidates compete with each other; and the two runner-ups move on to the second round. Our data capture voting participation in both rounds. For each district, we are able to observe the number of registered voters and the number of votes cast. Within the votes cast, we observe how many are valid or blank/invalid.

Registro Nacional de Denuncias de Delitos y Faltas. The *Registro Nacional de Denuncias de Delitos y Faltas* (National Registry of Crimes and Misdemeanors) collects crime-level information from each police station in Peru (Instituto Nacional de Estadística e Informática, 2017). Importantly, the registry includes information on the type of crime (e.g., violent versus economic crimes) and the district where each crime occurs. We use this to create a district-level panel of crimes per 10,000 residents for the years in which the registry is available (2011, 2013, 2014, 2016, and 2017).[17]

Registro Nacional de Municipalidades (RENAMU). The RENAMU (Municipality Registry) is an annual survey that collects information on the universe of municipalities (districts) in Peru

[17] For all calculations that involve normalizing by district population, we use data from the 2007 National Census (Instituto Nacional de Estadística e Informática, 2007a).

(Instituto Nacional de Estadística e Informática, 2007b). We use it to compute the number of public hospitals per 10,000 residents at the province level in 2007, the baseline year of our main estimation sample.

Censo Nacional de Comisarías (CENACOM). The CENACOM (National Census of Police Stations) is an annual census that collects information on police stations throughout Peru Instituto Nacional de Estadística e Informática (2012). We use the CENACOM to measure the number of police stations per 10,000 residents at the province level in 2012, the earliest available round of the census.

Latin American Public Opinion Project (LAPOP) and Latinobarómetro. We use data covering Peru from two other, nationally representative surveys: the AmericasBarometer of the Latin American Public Opinion Project (LAPOP Lab, 2017) and Latinobarómetro (Latinobarómetro Corporation, 2017). Both collect information on a variety of topics, including citizens' satisfaction with democracy. We use the 2014 and 2017 rounds of the LAPOP and the 2008-11, 2013, and 2015-2017 rounds of the Latinobarómetro. For both surveys, we restrict our attention to individuals in the Highlands as we do in our main regression sample.

4 Empirical Strategy

To estimate the causal effects of extreme cold shocks on political trust, we employ a fixed effects strategy. Specifically, we estimate the following regression:

$$Y_{idmt} = \beta_1 \text{CDH}_{idmt} + \beta_2 Z_{idmt} + \alpha_d + \gamma_t + \theta_m + \varepsilon_{idmt} \tag{4}$$

where Y_{idmt} is a measure of political trust for a randomly chosen adult from household i in district d interviewed in calendar month m of year t. CDH_{idmt} is the number of degree hours below threshold λ that a household experienced in the 12-month period before being interviewed. Z_{idmt} is a vector of predetermined individual and household characteristics (respondent sex, age, education level, mother tongue, relationship to the head of the household, altitude of the household, and household size) as well as weather controls (average temperatures and rainfall over the previous year).[18] We

[18]In section 5, we show that our results are not driven by the inclusion of controls.

include fixed effects at the district level (α_d) to account for time-invariant spatial heterogeneity in the incidence of cold shocks and political trust. We also include fixed effects at the interview year (γ_t) and month level (θ_m), which accounts for seasonality and general trends in political trust and cold shocks.

The coefficient of interest is β_1. The underlying identifying assumption is that the incidence and intensity of cold shocks are exogenous with respect to political trust, conditional on spatial and temporal fixed effects (and other controls, namely altitude). Though it is possible for households to sort into districts endogenously (for example, poorer households might be resigned to live in colder and less desirable areas), we exploit *within-district* variation in the intensity of cold shocks over time.[19] This means that our identifying variation comes from households within the same district who are interviewed (randomly) at different times — and thus who are subject to different temperature fluctuations that vary exogenously by the date of interview (after netting out general trends and seasonality in weather).[20] As long as households are unable to anticipate fluctuations in the intensity of cold shocks, $\hat{\beta}_1$ will capture the causal effect of extreme cold.[21]

5 Effects of Extreme Cold on Perceptions of Government

We find that cold weather shocks negatively affect individuals' perceptions of democracy. Exposure to an additional 10 degree hours below -9°C in the previous year reduces the probability an individual believes democracy works well (or very well) by 0.34 percentage points (pp) (Table 3, column 1).[22] Results using our preferred specification (which also includes individual and household controls, such as altitude) yield very similar results; an additional 10 degree hours below -9°C decreases positive perceptions by 0.38 pp (column 2); alternatively, a one standard deviation

[19] We further address the potential for endogenous migration in Section 5.1.

[20] The ENAHO is collected continuously throughout each survey year, in such as way that each quarterly dataset provides a nationally representative sample. This design allows for areas to be sampled more than once during any given year and provides random variation in the survey dates even within a given district.

[21] In Section 5.1, we discuss the results of a falsification exercise that suggests households cannot anticipate cold weather shocks.

[22] To simplify their interpretation, we have multiplied the coefficients and standard errors in all tables where outcomes are indicators or transformed using the hyperbolic sine by 100 so that they directly reflect changes in terms of percentage points or percent.

increase in CDH leads to a 0.44 pp decrease in positive perceptions.[23]

Table 3: Effects of Frost Shocks on the Belief that Democracy Works Well

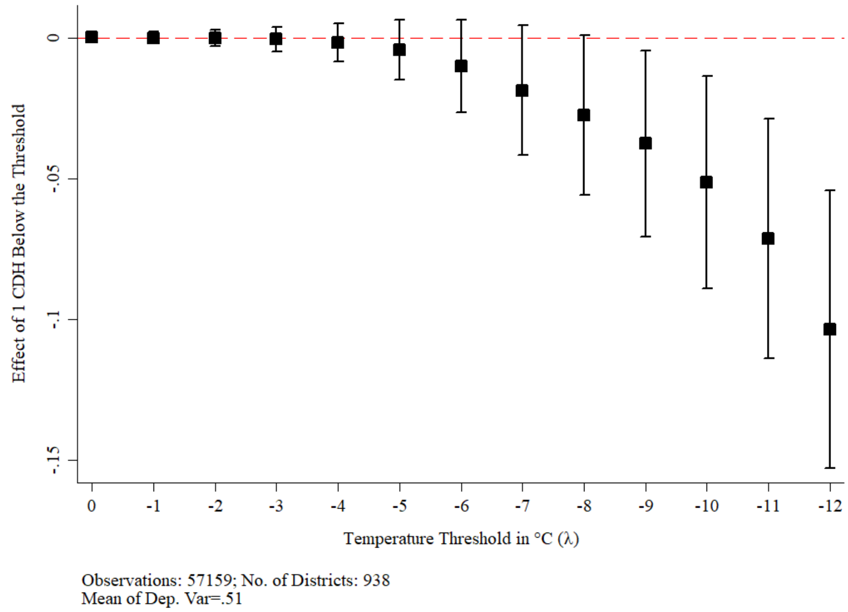
	Dep. Var.: Believes Democracy Works Well	
	Only Weather Controls	All Controls
	(1)	(2)
Cumulative Degree Hours (λ = -9°C)	-0.034**	-0.038**
	(0.017)	(0.017)
Observations	57159	57159
No. of Districts	938	938
Mean of Dep. Var	0.511	0.511

Notes: The sample includes individuals in all farming households in the Highlands using the 2007-2018 rounds of the ENAHO. All specifications include year, district, and month of interview fixed effects as well as average temperature and average rainfall at the household level for over the same reference period as the frost shock. Column 2 additionally includes controls for individual characteristics (respondent sex, age, and age squared as well as education level and mother tongue fixed effects), household size fixed effects, and altitude. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

The effects of cold weather shocks are larger if we consider more extreme thresholds of harmful temperatures (see Figure 1). For example, 10 degree hours below -12°C over the period of previous one year reduces the likelihood that a respondent believes democracy works well by 1.03 percentage points.

[23]The standard deviation of CDH in the sample is 1.17 degree hours.

Figure 1: Effect of Sub-zero Temperature Shocks on the Belief that Democracy Works Well



Notes: The sample includes individuals in all farming households in the Highlands using the 2007-2018 rounds of the ENAHO. Controls include average temperature and average rainfall over the same reference period as the frost shock, altitude at the household level, individual characteristics (respondent sex, age, and age squared as well as education level, mother tongue fixed effects, and household size). All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation.

5.1 Robustness Checks

The effect of extreme cold shocks on individuals' perceptions of democracy is robust to many alternate checks. First, we verify that our results hold in alternative samples and using other measures of political trust. To retain the full variation in the potential responses (from democracy functions "very poorly" to "very well"), we estimate an ordered probit and report the marginal effects of this regression in Appendix Table A1. We find similar results; frost shocks increase the likelihood of reporting democracy functions "poorly" or "very poorly" (Panel A). These patterns also hold when we include individuals who responded "don't know" as a neutral middle category – i.e., between "poorly" and "well" – in Panel B. Next, we show that the results are also consistent when we use a similar measure (satisfaction with democracy) as captured in the LAPOP and the Latinobarómetro.[24] In the LAPOP and Latinobarómetro samples, an additional 10-degree hours below -9°C lowers the probability that an individual in the Highlands is satisfied with the functioning of democracy by 8.4 percentage points and by 7.4 percentage points respectively (Appendix Table A2 columns 1 and 2).

Our results are also robust to using alternate measures of extreme cold (Appendix Table A3). We find that the effect is slightly larger if we aggregate CDH over shorter but more recent windows from the time of the interview (columns 2 and 3), suggesting that more recent weather shocks may be more salient for perceptions of government. We also find similar results using two other measures: cumulative degree days, a coarser but more common measure of temperature shocks[25] and a simple binary indicator for whether a household has experienced any frost shocks over the year prior to the survey; for example, each additional degree day below -9°C lowers positive perceptions by about 0.19pp (column 4) and experiencing any incidence of extreme cold below -9°C lowers positive perceptions by about 3.2pp (column 5).

Next, we demonstrate that our results are robust to alternate sources of identifying variation. In our main specification, we include district fixed effects, which are meaningful because districts are typically small in Peru (the average district is 680 km^2). To further control for unobserved spatial heterogeneity, we instead include conglomerate fixed effects in column 2 of Appendix Table A4.[26] Even with these finer-level fixed effects, we find similar (and even larger) estimated effects of frost shocks.

Another potential concern is that households may migrate as a response to past frost shocks. Such endogenous migration would mean that households who remain in areas experiencing relatively more frost shocks may systematically differ from those living in areas with fewer shocks. However, we do not find any meaningful differences in household characteristics by CDH

[24] We match weather data to individuals in the LAPOP and Latinobarómetro using the geographic centroid of the district where survey participants reside and the year and month of the interview; this is because geo-locations of the surveyed household are not collected in these surveys. It is also worth noting that the LAPOP and Latinobarómetro are much smaller surveys that with substantially lower coverage of districts.

[25] Similar to our primary measure (cumulative degree hours), cumulative degree days capture both the number of days temperatures dipped below a given threshold and by how much below the threshold the daily minimum temperature fell.

[26] Conglomerates are generally smaller than districts, though they constitute primary sampling units and not official administrative areas; our sample includes 2,985 conglomerates (compared to 938 districts).

(Appendix Table A5); though the relationship between frost shocks and having primary education or less is statistically significant (column 4), the magnitude of this relationship is extremely small and unlikely to explain our results. Additionally, in column 2 of Appendix Table A6, we show that the results are robust to restricting the sample to those who are currently living in their district of birth (so-called "non-movers"). We also directly assess whether households move in response to frost shocks and find no evidence that migration status is related to cold shocks (column 3).

Finally, to ensure that our measure of frost shocks captures exogenous weather shocks rather than systematic unobserved determinants or pre-existing trends in perceptions of democracy, we perform a simple falsification test where we estimate the "effect" of future cold weather events. Specifically, we estimate a version of equation 4 where instead of focusing on CDH in the 12 months prior to the survey, we include CDH in the 12 months *after* the interview date.[27] Column 2 of Appendix Table A7 shows no statistically significant relationship between perceptions of democracy and future realizations of extreme cold temperatures. This helps us rule out the possibility that households can anticipate future frost shocks, as well as the potential for frost shocks to capture unobserved determinants of perceptions of democracy that systematically vary across households and geographic areas. Finally, it also rules out the role of any possible differential pre-trends in perceptions of democracy that are related to frost shocks.

5.2 Mechanisms

This section explores potential pathways through which frost shocks can influence perceptions of democracy. We focus on three mechanisms: economic losses, adverse health hazards, and increased exposure to crime.

Economic Losses. First, we investigate whether exposure to extreme cold temperature shocks leads to economic losses through the reductions in agricultural revenue and productive assets (livestock). Anecdotal evidence suggests that episodes of extreme cold can result in crop failures and livestock death, thus entailing significant economics losses amongst agricultural households (Samora, 2021;

[27]Because we estimate the "effects" of a 12-month lead of CDH and have weather data only through 2018, for this analysis we have a restricted sample period from 2007-2017. Thus we begin by illustrating that our main results hold on this restricted sample period in column 1 of Appendix Table A7.

Barbier, 2010; The Guardian, 2021; FAO, 2008; BBC News, 2015). Agronomic literature highlights that crops — including those that are most commonly grown in Peru, such as maize and potatoes — suffer when exposed to cold temperatures, especially for longer periods or during critical stages of growth (Lee and Herbek, 2012; Carter and Hesterman, 1990; Hijmans et al., 2001; Burrows, 2019; Janssen, 2004; Romero et al., 1989).[28] Exposure to extreme cold temperatures can also be fatal for livestock, which are used by households as both productive assets and buffer stocks to be sold for cash in times of need (Escobal et al., 1999; Herrero et al., 2013).

We find that extreme cold substantially reduces agricultural revenue. Column 1 of Table 4 shows that an additional 10 degree hours below -9°C in the past year lowers annual agricultural revenue by 1.35% (column 1).[29] We also find that extreme cold harms households' livestock; an additional 10-degree hours below a threshold of -9°C in the previous 12 months translates into a 2.5 percent increase in monetary losses due to livestock deaths (column 2).[30] We also find that extreme cold increases individuals' perceptions of economic problems as a top priority issue; individuals exposed to extreme cold are more likely to report both "lack of agricultural support" and "lack of employment opportunities" as the single most pressing issue in the country (Appendix Table A9). This suggests that cold shocks influence households' understanding of broad economic issues for which they may hold governments accountable.

Health. Next, we estimate the effect of extreme cold on increased health hazards. Extreme cold can be harmful to health in terms of both population morbidity (Zhao et al., 2021; Kephart et al., 2022; Sheridan and Allen, 2015) and mortality (Deschenes and Moretti, 2009; Deschênes and Greenstone, 2011). Here we focus on the health of the elderly and the very young, motivated by the recognition that these groups are particularly vulnerable to extreme cold exposure (Kirkland, 2012; Centers for Disease Control and Prevention, 2024; Deschenes and Moretti, 2009). To the extent that cold

[28] In our setting, frost-sensitive crops account for the majority of the value of agricultural output. For example, maize and potato (both frost-sensitive crops according to agronomic studies) account for nearly half the agricultural output revenue of households (calculations based on the 2014-2018 National Agricultural Survey (Instituto Nacional de Estadística e Informática, 2018a).

[29] We transform all monetary outcomes using an inverse hyperbolic sine transformation (IHST) to interpret the effects of extreme cold in terms of percent changes while accounting for zero-valued observations. In practice, only 4 households in the sample do not have any crop revenue and about two thirds have no livestock deaths.

[30] On the extensive margin, we show that the same shock increases the likelihood of livestock death by 0.45 percentage points (column 1 of Appendix Table A8).

weather shocks affect ones own health or that of family members, they may lower individuals' trust in the government's ability to aid citizens in times of need. This is especially salient in low-income settings, where public health facilities and access to quality medical care are often scarce or insufficient. Indeed, Costello et al. (2015) find that child mortality rates were a significant predictor of violent and non-violent protests that took place as part of the "Arab Awakening".

We use two indicators that capture the incidence and severity of illness among adults age 65 and older and children 5 years and younger: the first is an indicator for whether the individual suffered from an illness requiring a medical consultation and the second is whether an individual was hospitalized.[31] Columns (3) and (4) of Table 4 show that 10-degree hours below a harmful threshold of -9°C increases the likelihood of any child illnesses and more "severe" illness (requiring hospitalization) by about 0.6 and 0.3 percentage points, respectively. These are meaningful effects on health, given that about a 30% of these individuals have required medical attention and 3.4% have been hospitalized in the past month.[32]

Crime. Earlier studies demonstrate that exposure to crime and victimization shape (mis)trust in democracy and institutions (Blanco and Ruiz, 2013; Blanco, 2013). Motivated by these findings, we test whether extreme cold shocks increase crime. As shown above, extreme cold events lead to significant economic losses, which in turn can spur criminal activity by increasing the value of crime as an alternate source of income (e.g. Iyer and Topalova, 2014; Blakeslee and Fishman, 2018; Mehlum et al., 2006). Indeed, previous work has shown that extreme heat increases crime, often through decreases in income (see for example (see, for example, Blakeslee and Fishman, 2018; Mukherjee and Sanders, 2021; Colmer and Doleac, 2022; Mares and Moffett, 2019; Garg et al., 2020; Simister, 2001; Simister and Cooper, 2005). As with the other mechanisms we study, increased crime tests the government's ability to provide an important public good – in this case, public safety and law and order – which in turn affects citizens' confidence and trust in government.

We test whether extreme cold results in crime using a panel of district-level crimes per 10,000 residents for the years in which the National Registry of Crimes and Misdemeanors was conducted

[31] Illness is reported within the 4 weeks prior to the survey interview. We match the household's weather data from the 8 weeks prior to the interview date to allow for extreme cold conditions to affect health with a lag.

[32] We pool age groups for precision, but in Appendix Table A10, we show that these results hold when consider vulnerable age groups separately, i.e., separately for those age 5 and under and those age 65 and over.

(2011, 2013, 2015, and 2017).[33] We focus on two types of crime that we believe are most likely to respond to extreme weather based on prior work: economic crimes (such as robbery and theft, extortion, fraud, and the sale of illicit goods) and violent crimes (such as murder, assaults, kidnapping, and rape). Economic crimes rise by 2% and total crimes by 1.2% for an additional 10-degree hours below -9°C (columns 5 and 7 in Table 4). In contrast, we find no statistically discernible effects on violent crimes (column 6), though the point estimate is positive.

Overall, the evidence in Table 4 suggests that extreme cold yields economic losses, worsens child health, and increases crime – all of which could be crucial for how individuals evaluate government capacity and perceive the efficacy of the democratic system.

6 Effects of Extreme Cold on Electoral Participation and Participation in Local Neighborhood Associations

Extreme cold appears to worsen individuals' perceptions of government. What are the downstream effects? We next examine the relationship between exposure to extreme cold temperature shocks and two key outcomes of interest: electoral participation and participation in local neighborhood associations. Ex ante, it is not clear whether extreme cold will increase or decrease voter participation. On the one hand, as cold events erode trust in the current government, citizens may choose to express discontent by voting against the incumbent party, leaving total voter turnout unchanged or even potentially increasing turnout. On the other hand, if extreme cold worsens perceptions of the broader system of democracy, disillusioned citizens may instead refrain from to engaging in elections altogether and voter turnout may fall. Indeed, in Western and established democracies, political distrust has been linked to voting absenteeism (Bélanger and Nadeau, 2005; Bélanger, 2017), though this topic remains less explored in the context of developing countries.

Moreover, individuals may seek additional sources of support from informal community-based institutions as an adaptive coping strategy to mitigate the negative consequences of extreme cold.

[33] We match weather data to the crime data using the geographic coordinates of each district's centroid and consider cumulative frost shocks 12 months prior to the calendar year of the crimes. We transform all crime variables using the inverse hyperbolic sine function to account for zeros (which are common for smaller districts).

Prior work suggests that in the face of economic shocks, households use local, community-based strategies to cope with economic uncertainties and consumption losses when high-level state and market-led opportunities for consumption smoothing are lacking (Bhattamishra and Barrett, 2010; Buggle and Durante, 2021). Thus, extreme cold may increase in engagement in local informal community-based associations.

Electoral Participation. To estimate the effects of extreme cold on electoral participation, we use district-level data from both rounds of voting in the 2011 and 2016 Presidential Elections (the two presidential elections during our study period). We consider two outcomes separately for each round of voting: the share of absent voters (i.e., the share of eligible voters in a district that did not cast a vote) and the total share of absent voters and blank votes (i.e., votes that are cast but left blank), which have been used as a measure of "protest" votes (Alvarez et al., 2018; Cohen, 2017). We measure CDH in the district in the year previous to the election, taking into account the date at which each voting round occurs.[34]

Extreme cold shocks leading up to a presidential election decrease voter participation: 10-degree hours below -9°C in the 12 months prior to the election increases the share of absent voters by 0.08 percentage points in the first round and by 0.10 percentage points in the second round of the elections (Table 5, columns 1 and 2).[35] These results are robust to including blank votes as an additional measure of non-participation (columns 3 and 4).[36] Though the effect size is modest, these results may have important implications, as the margin of victory in national elections tends to be very small in Peru. For example, a 10-degree hour shock translates into an increase of 22,766 absent voters nationally in the second round. The margin of victory in the 2016 presidential elections was 41,057, suggesting that the effect of extreme cold on absent voters could potentially play a meaningful role in election outcomes. Moreover, Appendix Figure A5 shows the effect is larger for higher thresholds of the shock. Overall, these results align with recent findings in other contexts,

[34]By definition, CDH does not include weather in the month of the election so that we do not capture the effects of any cold events that occur on election day that may directly affect voters' ability or willingness to go to the polls.

[35]In our main specification, we weight by the number of registered voters in each district-election year cell. The results are very similar without weights (Appendix Table A11).

[36]In column 3 of Appendix Table A2, we show that our results are robust to using individual self-reports of voting behavior in the LAPOP data. Consistent with the results using official district level voting data, we find that individuals are more likely to report that they did *not* vote when they are exposed to frost shocks in the year prior to the election.

where awareness of weak public service delivery reduces the likelihood of voting (Cox et al., 2024). These results are also consistent with interpreting the worsening of perceptions of government as partly reflecting a decline in confidence in the broad system of democracy (i.e., a decline in so-called "diffuse" support for democracy), rather than a decrease in support for specific government actors (such as the incumbent leaders).

Participation in Local Associations. To investigate whether extreme cold shocks impact engagement in local institutions, we evaluate households' participation in three categories of associations[37]: political (e.g., political parties, municipal management committees, citizen round tables), professional and agricultural (e.g., worker associations, trade guilds, professional associations, agricultural associations), and community-based (e.g., peasant communities in charge of communal land administration, rural self-defense groups, neighborhood associations).[38] Overall participation in local associations increases by 0.23 percentage points when households face 10-degree hours below -9°C (Table 6, column 1). This estimated effect does not appear to be driven either by participation in political (column 2) or professional and agricultural associations (column 3) but rather by community-based associations (column 4). As with our main results, we find that the effects of cold weather shocks on participation in local organizations are larger when we consider more extreme temperature thresholds (see Appendix Figure A6). Using the 2014 and 2017 rounds of the LAPOP, we find that exposure to extreme cold also increases the likelihood that respondents report people in their community are trustworthy (column 4 of table A2), indicating that adverse weather shocks can yield higher interpersonal trust, consistent with previous work (Buggle and Durante, 2021).

Overall, these results indicate that extreme cold shocks reduce participation in formal, national institutions (such as voting) and increase engagement in local, informal institutions related to identity, kinship, and social proximity.

[37]Our measure of participation in local organizations aims to highlight how citizens self-organize to cope with adverse shocks. Therefore, we exclude participation in government-run social assistance programs (such as *Vaso de Leche* and *Comedores Populares*).

[38]Prior to the 2012 round of the ENAHO, participation in *Comunidades Campesinas* (a historical and widespread community-based group) was not asked about directly, but was included in the category "Other". As a result, we include the "Other" category prior to 2012 in the community-based definition.

7 Can Access to Public Goods and Services Improve Political Trust and Electoral Participation in the Wake of Adverse Shocks?

How can governments mitigate the effects of cold shocks on citizens' perceptions and political trust? Our mechanism analysis suggests that the extreme cold worsens perceptions primarily through income losses, increased illness, and elevated crime. Thus one might expect that government provision of goods and services – specifically, ones that address these needs, such as social program support, public health facilities, and public safety resources – will lessen the adverse impacts of extreme cold on citizens' perceptions of government. With this in mind, we explore the heterogeneous impacts of frost shocks by a composite indicator of access to social assistance programs, public hospitals, and police stations.[39]

We construct the measure of public goods and services, using baseline measures of access to social programs (the province-level share of households benefiting from at least one social program), public health facilities (public hospitals per 10,000 residents at the province level), and police resources (police stations per 10,000 residents at the province level).[40] Data on social program access and police stations are only available starting in 2012, so we use the period 2013-2018 as the sample period for this analysis to avoid any endogenous responses of public goods and service provision to perceptions of government.[41] We combine the three dimensions of public goods and services into a single index using principal component analysis. For simplicity, we construct an indicator variable identifying provinces as being or below the median value of the composite index.

We begin by demonstrating that our main results in this restricted sample period (column 1 of Table 7) are nearly identical to those using the full sample period (column 2 of Table 3). In column 2 of Table 7, we see that the negative impact of CDH on political trust is lower in places with a higher coverage of public goods and services. In provinces with below-median baseline

[39]Several studies find that redistributive programs such as cash transfers can directly foster support for government (Evans et al., 2019; Kosec and Mo, 2023), though effects may be short-lived (Zucco Jr, 2013).

[40]Social program access is measured in the 2012 ENAHO, public hospitals are measured in the 2007 RENAMU, and police stations are surveyed in the 2012 CENACOM.

[41]For electoral participation analysis, we continue to use voting data from both 2011 and 2016 because restricting the sample to 2016 data (the only round after 2012) would limit us to using only cross-sectional variation in weather shocks. Admittedly, this leaves open the possibility that 2011 voting outcomes directly affect public good provision in 2012 - thus we regard the heterogeneity results for voting outcomes as suggestive.

coverage of public goods and services, 10-degree hours below -9°C in the previous 12 months reduces political trust by 0.65 percentage points. In contrast, the same shock in provinces with an above-median baseline coverage reduces political trust by only 0.27 percentage points, though this difference is not statistically significant. Similarly, higher public goods provision mitigates some of the effects of extreme cold on voter absenteeism. In areas with below-median provision of public goods and services, cold shocks lead to a higher share of absent voters than in areas with above-median provision, though that difference is only sizeable and significant for the second round of voting (columns 3 and 4).[42] In provinces with below-median coverage of public goods and services, a 10-degree hours below -9°C in the previous 12 months from the time of the second round election can increase voter absenteeism by 0.16 percentage points, whereas this effect is only 0.09 percentage points in above-median provinces (column 4).[43]

8 Conclusion

This study sheds light on the impact that extreme weather conditions have on individuals' perceptions of democracy. Extreme cold temperature shocks significantly decrease in the belief that democracy functions well in Peru. This, in turn, reduces civic engagement in formal, national institutions, as reflected by lower participation in national elections. These findings are consistent with extreme cold reducing support and confidence in the broader system of democracy, rather than decreasing support for a specific political actor or government body. We also observe a corresponding increase in participation in local associations, suggesting households look for alternative forms of civic involvement in an attempt to seek additional sources of support from more informal community-based institutions in the face of a shock.

Furthermore, our research explores the underlying mechanisms through which extreme cold affects perceptions. We find that decreased income, assets, and expenditure, along with an increased

[42] In Appendix TableA12, we show that these patterns are also consistent when we consider both absent and blank votes as the measure of voter (non)participation.

[43] Interestingly, we find no corresponding heterogeneity in the effects of extreme cold on participation in local associations (Appendix Table A13). This suggests that in this context, there is no substitution between formal and informal channels of risk mitigation strategies, adding to the mixed evidence on crowding out amongst formal and informal sources of support (Banerjee et al., 2024).

incidence of illness and crimes, contribute to the negative effects on individuals' beliefs about democracy and government.

Importantly, our findings indicate that government provision of goods and services can mitigate the adverse effects of extreme cold. Higher coverage of public goods and services in the form of access to social programs, public hospitals, and police resources play a crucial role in attenuating political mistrust and voter absenteeism brought about by extreme weather shocks.

Overall, these results emphasize the importance of considering weather-related factors when examining the dynamics of citizens' beliefs about government and democracy more broadly. These findings underscore the need for governments to be attentive to extreme weather events and to prioritize the provision of essential services during such periods of crisis, as this can help maintain or restore confidence in democratic processes and institutions.

Table 4: Effects of Frost Shocks on Agricultural Income, Livestock Assets, and Crime

	Economic Outcomes		Health		Crimes		
	Agric. Revenue	Val. of Livestock Deaths	Individual Required Medical Attention	Individual Was Hospitalized	Economic Crimes	Violent Crimes	Total Crimes
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CDH (λ = -9°C)	-0.135***	0.251*	0.059***	0.029***	0.204***	0.090	0.122**
	(0.042)	(0.141)	(0.014)	(0.004)	(0.063)	(0.075)	(0.058)
Observations	76642	63028	63084	63076	5390	5390	5390
No. of Districts	944	922	937	937	1072	1072	1072
Mean of Dep. Var	2746.530	582.943	0.302	0.034	19.700	14.553	40.275

Notes: Outcomes in columns 1-2 and 5-7 have been transformed using the inverse hyperbolic sine function. The sample for columns 1-2 includes all households in the Highlands with agricultural revenue over the previous year using the 2007-2018 rounds of the ENAHO; it is further restricted to individuals under the age of 5 or over 65 in these households in Columns 3-4. The sample for columns 5-7 includes all districts in the Highlands using all available crime data from the 2011, 2013, 2015, 2016, and 2017 rounds of the National Registry of Crimes and Misdemeanors. Controls include average temperature and average rainfall over the same reference period as the frost shock and altitude. Columns 1-2 also include household head characteristics (sex, age, and age squared as well as education level and mother tongue fixed effects), log of total land (owned + rented), and household size fixed effects. Columns 3-4 also include individual's sex and age fixed effects as well as household head characteristics and household size fixed effects. All specifications in columns 1-4 include year, district, and month of interview fixed effects. All specifications in columns 5-7 include year and district fixed effects as well as province-specific time trends. District-level clustered standard errors in parentheses. District-level clustered standard errors in parentheses. All coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: Effects of Frost Shocks on Electoral Participation

	Share of Absent Votes		Share of Absent & Blank Votes	
	First Round	Second Round	First Round	Second Round
	(1)	(2)	(3)	(4)
CDH (λ = -9°C)	0.008***	0.010***	0.007***	0.011***
	(0.001)	(0.002)	(0.001)	(0.002)
Observations	2546	2546	2546	2546
No. of Districts	1278	1278	1278	1278
Mean of Dep. Var	0.187	0.211	0.297	0.220

Notes: Shares are calculated with respect to the total eligible voters in each district. Weather variables are measured at the district centroid and measures weather in the year prior to the date of each election. The sample includes all districts in the Highlands and covers the 2011 and 2016 presidential elections. All specifications include year and district fixed effects. Observations are weighted by the number of registered voters in each district and election round. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Effects of Frost Shocks on Participation in Local Associations

	All Local Assoc.	Political & Government	Professional & Agricultural	Community-Based
	(1)	(2)	(3)	(4)
CDH (λ = -9°C)	0.024**	0.000	0.004	0.031**
	(0.010)	(0.001)	(0.017)	(0.014)
Observations	76471	76471	76471	76471
No. of Districts	944	944	944	944
Mean of Dep. Var	0.816	0.012	0.182	0.703

Notes: The sample includes individuals in all farming households in the Highlands using the 2007-2018 rounds of the ENAHO. Controls include average temperature, average rainfall, altitude at the household level for over the same reference period as the frost shock, household head characteristics (sex, age, age squared, education level, and mother tongue), and household size. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Heterogeneous Effects by Public Provision Coverage

	Democracy Works Well		Share of Absent Voters	
			First Round	Second Round
	(1)	(2)	(3)	(4)
CDH (λ = -9°C)	-0.036**	-0.065**	0.009***	0.016***
	(0.018)	(0.032)	(0.003)	(0.004)
CDH (λ = -9°C) X Above Median Public Goods & Services		0.038	-0.001	-0.007*
		(0.036)	(0.003)	(0.004)
Total Effect for Above-Median Provinces		-0.027*	0.008***	0.009***
		(0.016)	(0.001)	(0.001)
Observations	34295	34089	2502	2502
No. of Districts	890	883	1256	1256
Mean of Dep. Var	0.555	0.555	0.187	0.211

Provincial-level baseline public goods and services provision is measured using the first and second principal components of household participation in social programs (from the 2012 ENAHO), public hospitals per 10,000 residents (from the 2007 RENAMU), and police stations per 10,000 residents (from the 2012 CENACOM). For Columns (1) & (2) the sample includes individuals in all farming households in the Highlands using the 2013-2018 rounds of the ENAHO. Controls include average temperature, average rainfall, altitude at the household level for over the same reference period as the frost shock, individual characteristics (respondent sex, age, and age squared, education level, and mother tongue), and household size. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. For Columns (3)- (4): Shares are calculated with respect to the total eligible voters in each district. The sample includes all districts in the Highlands and covers the 2011 and 2016 presidential elections. Weather variables are measured at the district centroid and measures weather in the year prior to the date of each election. All specifications include year and district fixed effects. District-level clustered standard errors in parentheses. Regression weighted by district-level number of registered voters in each election. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

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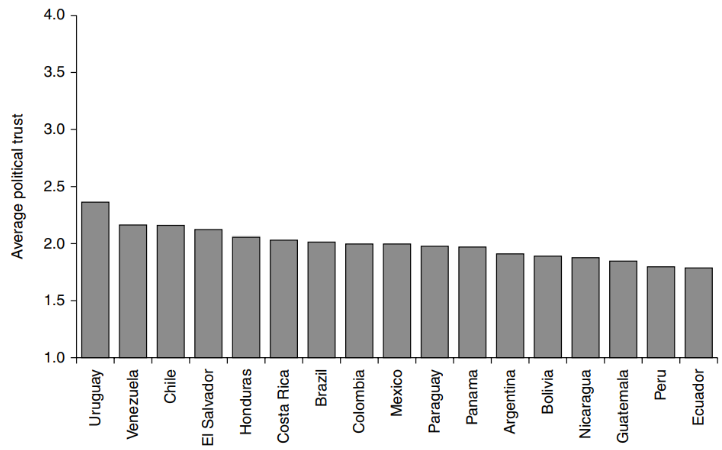
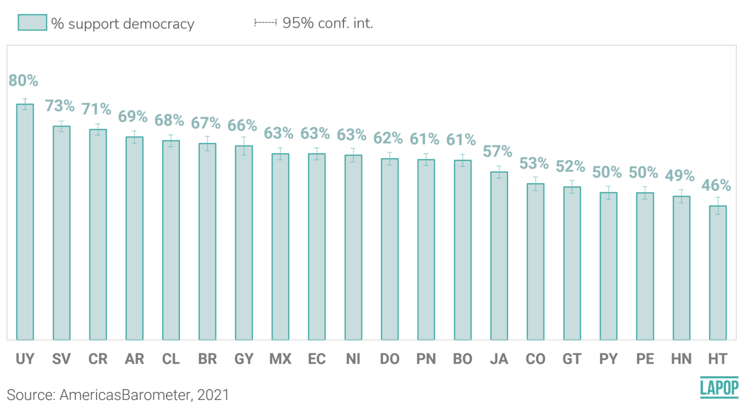
A Appendix: Figures and Tables

Figure A1: Trust in Political Institutions in Latin America (1996-2011)



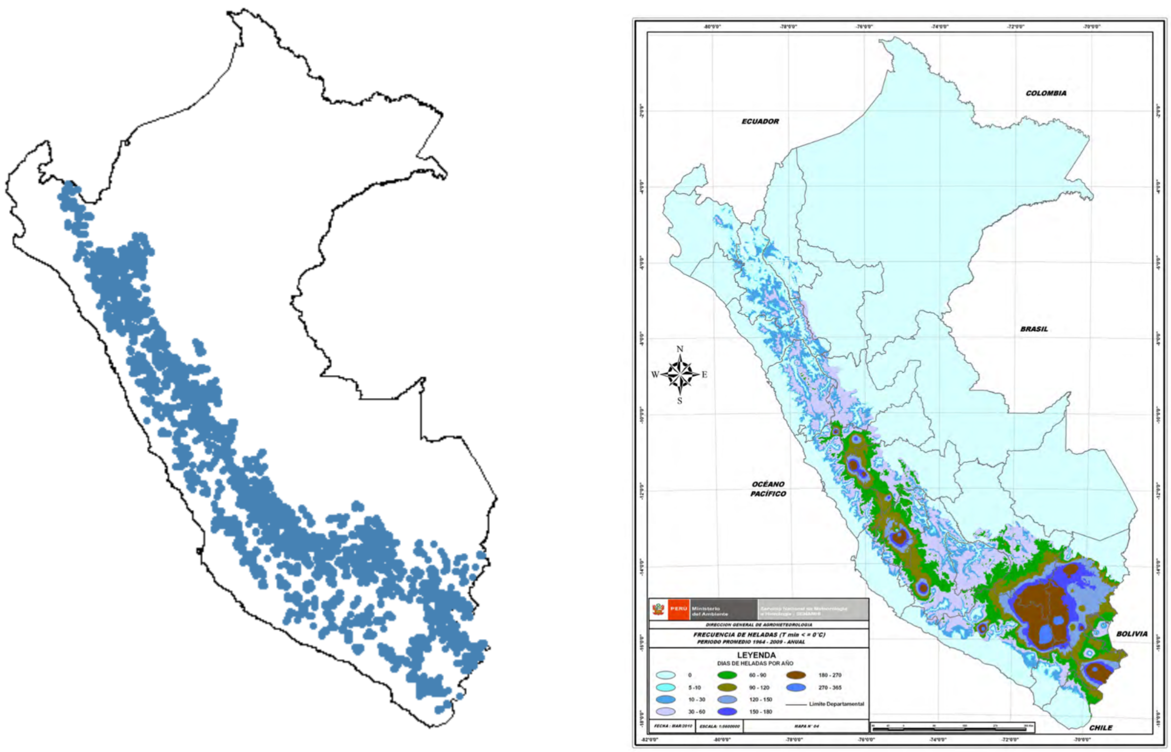
Source: Bargsted et al. (2017) , Handbook of Political Trust. The index is an average of trust in three political institutions (the national congress, political parties, and the government), averaged over the period 1996-2011.

Figure A2: Preferences for Democracy in Latin America, 2021



Source: LAPOP (2021). The chart is based on respondents' answers to the following question: *"Democracy may have problems, but it is better than other forms of government. To what extent do you agree with this statement?"*. Responses ranged from one (strongly disagree) to seven (strongly agree). Those whose responses were five, six, or seven were considered to support democracy.

Figure A3: Location of the ENAHO observations across the Peruvian Highlands used in this study



(a) Location of Households in this Study, from ENAHO

(b) Incidence of Frosts in Peru (1964–2009)

Notes: The left panel (Figure A3a) presents the location of the sample of rural households from the Peruvian highlands in this study (2007-2018). The right panel (Figure A3b) was taken from SENAMHI (2010) (p.47). It presents the average number of frost days per year between 1964 and 2009.

Figure A4: Percentage of Households Facing Shocks at Different Temperature Thresholds

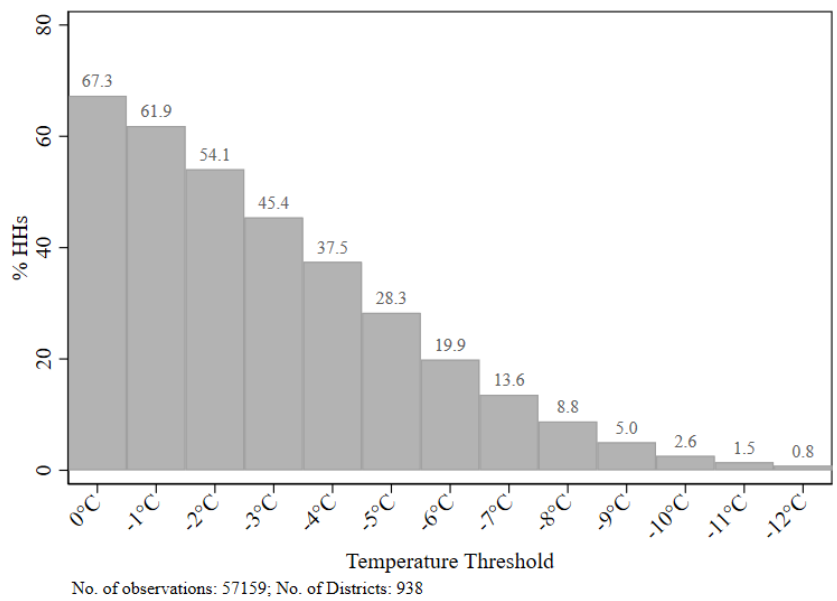


Table A1: Ordered Probit Models (Marginal Effects)

	A. Dep. Var.: Believes Democracy Works Well (categories)				
	Very Poorly	Poorly	Don't Know	Well	Very Well
	(1)	(2)	(3)	(4)	(5)
CDH (λ = -9 °C)	0.010***	0.024***	–	-0.004***	-0.001***
	(0.003)	(0.006)	–	(0.001)	(0.0003)
N. of obs.			57159		

	B. Dep. Var.: Believes Democracy Works Well (categories)				
	Very Poorly	Poorly	Don't Know	Well	Very Well
	(6)	(7)	(8)	(9)	(10)
CDH (λ = -9 °C)	0.005*	0.014*	0.0002*	-0.017 *	-0.002*
	(0.003)	(0.008)	(0.0001)	(0.009)	(0.0013)
N. of obs.			75632		

Notes: Columns 1-5: Dependent variable is categorical and takes 4 distinct values (omitting "Don't Know"). Columns 6-10: Dependent variable is categorical and takes 5 distinct values (including "Don't Know" as a "middle" category). The sample includes individuals in all farming households in the Highlands using the 2007-2018 rounds of the ENAHO. Controls include average temperature and average rainfall at the household level over the same reference period as the frost shock, individual characteristics (respondent sex, age, age squared, education level, and mother tongue), altitude, and fixed effects for household size. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Marginal Effects and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Table A2: Using Alternative Datasets

	Is Satisfied with Democracy		Did Not Vote in Last Presidential Election	Trust People in Community
	LAPOP	Latinobarometer	LAPOP	LAPOP
	(1)	(2)	(3)	(4)
CDH (λ = -9°C) in Year Prior to Survey	-0.835***	-0.742***		0.591*
	(0.243)	(0.216)		(0.324)
CDH (λ = -9°C) in Year Prior to Election			2.198*	
			(1.146)	
Observations	1053	2819	1544	1096
No. of Districts	47	33	84	47
Mean of Dep. Var	0.324	0.199	0.087	0.485

Notes: Sample is restricted to districts in the Highlands and includes the 2014 and 2017 rounds of the LAPOP in column 1; the 2008-2011, 2013, 2015-2017 rounds of the Latinobarometer in column 2; the 2006, 2012, and 2017 rounds of the LAPOP in column 3; and 2014 and 2017 rounds of LAPOP for column 4. Weather variables are measured at the district centroid and measures weather in the year prior to the interview month and year in columns 1 and 2 and in the year prior to the election month and year in column 3. Controls include respondent sex, age, and age squared as well as education level fixed effects. Columns 1 and 2 include year, district, and month of interview fixed effects; column 3 includes election year and district fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Table A3: Effects Using Alternate Measures of Frost Shocks

	Dep. Var.: Believes Democracy Works Well				
	(1)	(2)	(3)	(4)	(5)
CDH over past 12 months (λ = -9°C)	-0.038**				
	(0.017)				
CDH over past 6 months (λ = -9°C)		-0.055***			
		(0.018)			
CDH over past 3 months (λ = -9°C)			-0.040***		
			(0.015)		
Cumulative Degree Days (λ = -9°C)				-0.186*	
				(0.103)	
Any shock over past 12 months (λ = -9°C)					-3.206*
					(1.674)
Observations	57159	57159	57159	57159	57159
No. of Districts	938	938	938	938	938
Mean of Dep. Var	0.511	0.511	0.511	0.511	0.511

Notes: The sample includes all individuals in farming households in the Highlands using the 2007-2018 rounds of the ENAHO. Controls include average temperature and average rainfall over the same reference period as the frost shock, altitude at the household level, individual characteristics (respondent sex, age, and age squared as well as education level and mother tongue fixed effects), and household size fixed effects. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Table A4: Effects Using Alternate Fixed Effects

	Dep. Var.: Believes Democracy Works Well	
	District FE (Baseline)	Conglome FE
	(1)	(2)
Cumulative Degree Hours (λ = -9°C)	-0.038**	-0.066***
	(0.017)	(0.019)
Observations	57159	56823
No. of Districts	938	932
No. of Groups for FE	938	2985
Mean of Dep. Var	0.511	0.512

Notes: The sample includes individuals in all farming households in the Highlands using the 2007-2018 rounds of the ENAHO. Controls include average temperature and average rainfall at the household level over the same reference period as the frost shock, individual characteristics (respondent sex, age, and age squared as well as education level and mother tongue fixed effects), altitude, and household size fixed effects. All specifications include year and month of interview fixed effects, as well as fixed effects at the level indicated in each column. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Table A5: Frost Shocks and Sample Composition

	Male (1)	Age (2)	Household Size (3)	Primary Education (4)	Speaks Quechua (5)
CDH (λ = -9°C)	0.0000	-0.0012	0.0005	0.0003***	0.0000
	(0.0001)	(0.0032)	(0.0005)	(0.0001)	(0.0001)
Observations	57159	57159	57159	57159	57159
No. of Districts	938	938	938	938	938
Mean of Dep. Var	0.509	46.724	4.014	0.628	0.518

Notes: The sample includes individuals in all farming households in the Highlands using the 2007-2018 rounds of the ENAHO. Except when used as an outcome, controls include average temperatureand average rainfall at the household level over the same reference period as the frost shock, individual characteristics (respondent sex, age, age squared, education level fixed effects, mother tongue); altitude, and household size. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Table A6: Assessing Endogenous Migration

	Dep. Var.: Believes Democracy Works Well		Dep. Var.: Migrated
	Full Sample	Non-movers	Full Sample
	(1)	(2)	(3)
CDH (λ = -9°C)	-0.038**	-0.033*	-0.009
	(0.017)	(0.018)	(0.010)
Observations	57159	46907	57151
No. of Districts	938	913	938
Mean of Dep. Var	0.511	0.518	0.179

Notes: The sample includes individuals in all farming households in the Highlands using the 2007-2018 rounds of the ENAHO; in column 2, the sample is further restricted to individuals who reside in their district of birth (non-movers). Controls include average temperature and average rainfall at the household level over the same reference period as the frost shock, individual characteristics (respondent sex, age, age squared, education level fixed effects, mother tongue), altitude, and household size. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Table A7: Falsification Test: Effects of Future Frost Shocks

	Dependent Variable: Believes Democracy Works Well	
	(1)	(2)
CDH (λ = -9°C) in the *Previous* 12 Months	-0.043***	
	(0.016)	
CDH (λ = -9°C) in the *Next* 12 Months		0.011
		(0.012)
Observations	50701	50701
No. of Districts	902	902
Mean of Dep. Var	0.515	0.515

Notes: The sample includes all individuals in farming households in the Highlands using the 2007-2017 rounds of the ENAHO. Controls include average temperature and average rainfall at the household level over the same reference period as the frost shock, individual characteristics (respondent sex, age, and age squared as well as education level and mother tongue fixed effects), altitude, and household size fixed effects. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Table A8: Effects of Frost Shocks on Livestock Assets

	Any Livestock Death	Log Value of Livestock Deaths
	(1)	(2)
CDH (λ = -9°C)	0.045*	0.251*
	(0.025)	(0.141)
Observations	63028	63028
No. of Districts	922	922
Mean of Dep. Var	0.339	582.943

Notes: Value of livestock deaths has been transformed using the inverse hyperbolic sine function. The sample includes all farming households using the 2007-2018 rounds of the ENAHO. Controls include average temperature, average rainfall, altitude at the household level for over the same reference period as the frost shock, household head characteristics (sex, age, and age squared, education level and mother tongue), log of total land (owned + rented), and household size. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1. Mean value of livestock deaths are expressed in 2007 soles using the GDP deflator published by World Bank (2023).

Table A9: Effects of Frost Shocks on Subjective Perceptions

	Country's Highest Priority Problem is...	
	Lack of Ag. Support	Lack of Employment
	(1)	(2)
CDH (λ = -9°C)	0.017***	0.014***
	(0.005)	(0.006)
Observations	75632	75632
No. of Districts	940	940
Mean of Dep. Var	0.076	0.063

Notes: The sample for columns includes all households in the Highlands with agricultural revenue over the previous year using the 2007-2018 rounds of the ENAHO. Controls include average temperature and average rainfall over the same reference period as the frost shock and altitude, household head characteristics (sex, age, and age squared as well as education level and mother tongue fixed effects), and household size fixed effects. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. District-level clustered standard errors in parentheses. All coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

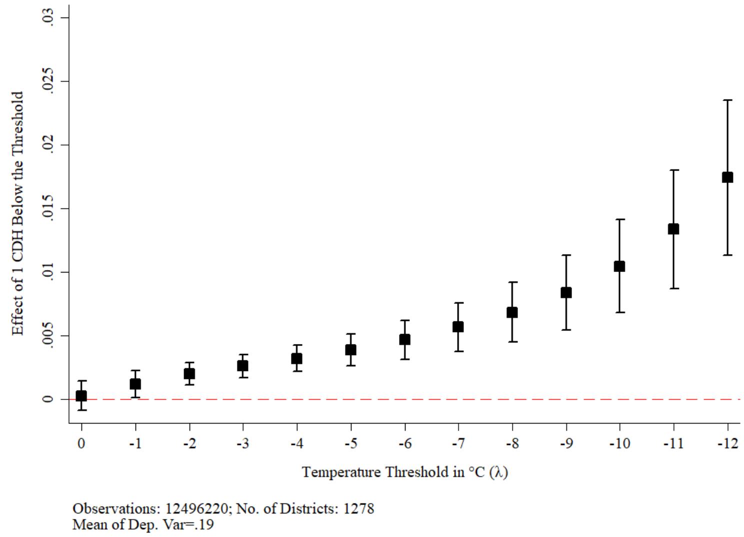
Table A10: Effects of Frost Shocks on Health

	Individual Required Medical Attention		Individual Was Hospitalized	
	Age $\leq$ 5	Age $\geq$ 65	Age $\leq$ 5	Age $\geq$ 65
	(1)	(2)	(3)	(4)
Cumulative Degree Hours (λ = -9°C)	0.199***	0.044***	0.028	0.029***
	(0.066)	(0.014)	(0.029)	(0.003)
Observations	29242	33811	29240	33805
No. of Districts	887	918	887	918
Mean of Dep. Var	0.311	0.295	0.022	0.045

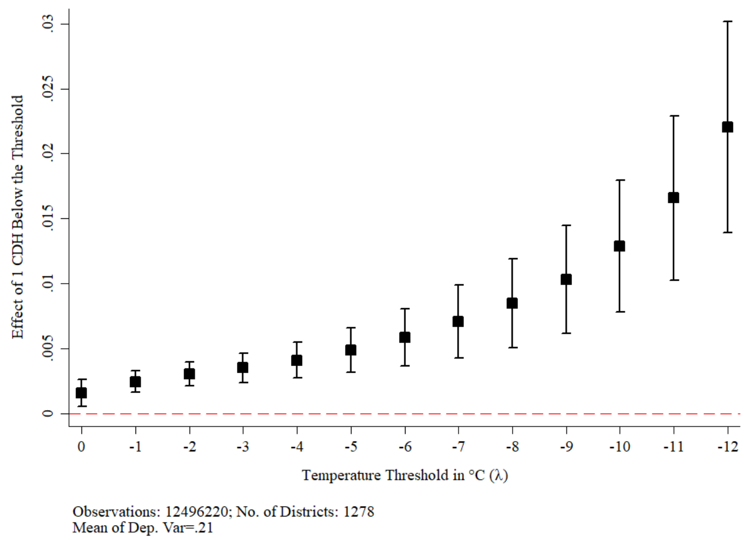
Notes: The sample includes all individuals 5 and under (columns 1 and 3) or individuals 65 and over (coluns 2 and 4) living in farming households in the Highlands using the 2007-2018 rounds of the ENAHO. Controls include average temperature and average rainfall at the household level over the same reference period as the frost shock, altitude, household head characteristics (sex, age, and age squared as well as education level and mother tongue fixed effects), individual sex and age fixed effects, and household size fixed effects. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Figure A5: Effect of Sub-zero Temperature Shocks on the Share of Absent Voters in Presidential Elections

(a) First Round



(b) Second Round



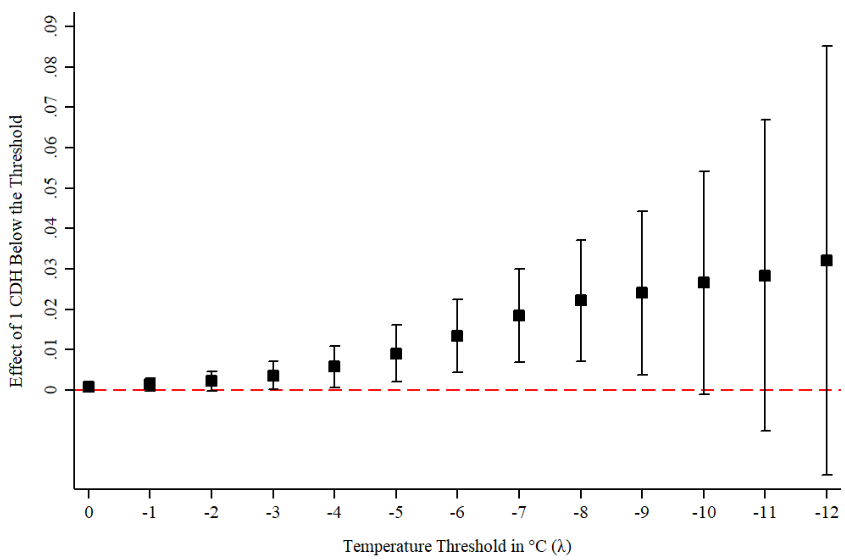
Notes: Shares are calculated with respect to the total eligible voters in each district. The sample includes all districts in the Highlands and covers the 2011 and 2016 presidential elections. Weather variables are measured at the district centroid and measures weather in the year prior to the date of each election. All specifications include year and district fixed effects. District-level clustered standard errors in parentheses. Regression weighted by district-level number of registered voters in each election. Coefficients and standard errors have been multiplied by 100 for ease of interpretation.

Table A11: Effects of Frost Shocks on Electoral Participation (Unweighted)

	Share of Absent Votes		Share Absent & Blank	
	First Round	Second Round	First Round	Second Round
	(1)	(2)	(3)	(4)
CDH (λ = -9°C)	0.008***	0.013***	0.007***	0.013***
	(0.002)	(0.003)	(0.002)	(0.003)
Observations	2536	2536	2536	2536
No. of Districts	1268	1268	1268	1268
Mean of Dep. Var	0.235	0.263	0.363	0.273

Notes: Shares are calculated with respect to the total eligible voters in each district. The sample includes all districts in the Highlands and covers the 2011 and 2016 presidential elections. Weather variables are measured at the district centroid and measures weather in the year prior to the date of each election. All specifications include year and district fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.

Figure A6: Effect of Sub-zero Temperature Shocks on Participation in Local Associations



Observations: 76471; No. of Districts: 944
Mean of Dep. Var=.82

Notes: The sample includes individuals in all farming households in the Highlands using the 2007-2018 rounds of the ENAHO. Controls include average temperature, average rainfall , altitude at the household level for over the same reference period as the frost shock, household head characteristics (sex, age, age squared, education level, and mother tongue), and household size. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation.

Table A12: Heterogeneous Effects by Public Provision Coverage

	Share of Absent + Blank Votes	
	First Round	Second Round
	(1)	(2)
CDH (λ = -9°C)	0.007***	0.016***
	(0.002)	(0.004)
CDH (λ = -9°C) X Above Median Public Goods & Services	-0.000	-0.007*
	(0.002)	(0.004)
Total Effect in Above-Median Provinces	0.007***	0.010***
	(0.001)	(0.001)
Observations	2502	2502
No. of Districts	1256	1256
Mean of Dep. Var	0.297	0.220

Provincial-level baseline public goods and services provision is measured using the first and second principal components of household participation in social programs (from the 2012 ENAHO), public hospitals per 10,000 residents (from the 2007 RENAMU), and police stations per 10,000 residents (from the 2012 CENACOM). Shares are calculated with respect to the total eligible voters in each district. The sample includes all districts in the Highlands and covers the 2011 and 2016 presidential elections. Weather variables are measured at the district centroid and measures weather in the year prior to the date of each election. All specifications include year and district fixed effects. District-level clustered standard errors in parentheses. Regression weighted by district-level number of registered voters in each election. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A13: Heterogeneous Effects of Participation in Local Associations by Public Provision Coverage

	Local Association Participation
	(1)
CDH (λ = -9°C)	-0.006
	(0.025)
CDH (λ = -9°C) X Above Median	0.030
Public Goods & Services	(0.025)
Total Effect in	0.024***
Above-Median Provinces	(0.006)
Observations	43648
No. of Districts	890
Mean of Dep. Var	0.823

Provincial-level baseline public goods and services provision is measured using the first and second principal components of household participation in social programs (from the 2012 ENAHO), public hospitals per 10,000 residents (from the 2007 RENAMU), and police stations per 10,000 residents (from the 2012 CENACOM). The sample includes individuals in all farming households in the Highlands in the 2013 - 2018 rounds of the ENAHO. Controls include average temperature and average rainfall over the same reference period as the frost shock, altitude at the household level, household head characteristics (sex, age, age squared, education level, and mother tongue), and household size. All specifications include year, district, and month of interview fixed effects. District-level clustered standard errors in parentheses. Coefficients and standard errors have been multiplied by 100 for ease of interpretation. Significance levels denoted by: *** p<0.01, ** p<0.05, * p<0.1.