Climate Risk and Entrepreneurial Efforts: Evidence from Droughts in Chile

Abstract

This paper studies the effects of droughts on individual entrepreneurial efforts based on necessity and opportunity in Chile. Using an extensive database on 35 thousand individuals between 2006 and 2014, we demonstrate that droughts have significant effects on early-stage entrepreneurial activities in different regions of Chile. In particular, we show that increases in droughts are positively associated with the likelihood of individuals becoming entrepreneurs because of both necessities and opportunities. Further, we examine the industries' profiles from early-stages entrepreneurs and their relationships to regional drought vulnerabilities. We find evidence that droughts increase the probability of an individual willing to start up a new venture related to retail and consumer service activities as they have to reinvent themselves from traditional agriculture and extractive businesses. Our results illustrate that climate change risks have a meaningful impact on both opportunity and necessity-driven entrepreneurial efforts.

Keywords: Climate Entrepreneurship; Climate Change; Droughts; Global Entrepreneurship Monitor; Chile.

1. Introduction

Climate change is one of the key economic challenges of our time. The impacts of climate change present serious risks for the economy. Many industries, such as mining, agriculture, and real estate, are particularly concerned about the risks generated by being exposed to temperatures increasing, rising sea levels, and extended periods of droughts that can adversely affect their cash flows and profits.

There is broad consensus in the scientific community on human-induced climate change and its impact (Wolfson & Schneider, 2002); however, fundamental doubts remain, and disagreements and debates continue. For instance, President Donald Trump has mostly denied the existence of global warming and rolled back regulations intended to mitigate climate-change risks. Meanwhile, The Green New Deal introduced by U.S. Representative Alexandria Ocasio-Cortez and U.S. Senator Edward Markey, both Democrats, proposes to transform America's energy system to 100 percent renewables by 2030 with complete decarbonization of the economy by 2050. In the face of a highly politicized debate, in this paper, we provide evidence revealing some of the real cost of climate change and their connection to entrepreneurial activities. In particular, we focus on the influences of droughts on individual entrepreneurial efforts driven by necessity and opportunity in Chile.

Indeed, climate change will not mean the end of the world, but as The Economists put it in its special issue last September 2019: ¨*Climate change is, though, a dire threat to countless people—one that is planetary in scope if not in its absolute stakes. It will displace tens of millions, at the very least; it will disrupt farms on which billions rely; it will dry up wells and water mains; it will flood low-lying places—and, as time goes by, higher-standing ones, too. True, it will also provide some opportunities, at least in the near term. But the longer humanity takes to curb emissions, the*

greater the dangers and sparser the benefits—and the larger the risk of some truly catastrophic surprises."[1]

Among the effects caused by climate change are the increases in the occurrence of natural disasters such as hurricanes, storms, floods, and droughts. Among these natural disasters, drought is considered one of the most harmful for the Chilean economy, which is mainly based on water-intensive mining and agricultural activities. Together these two industries represent about 13 percent of the Chilean GDP. In the case of mining, access to a reliable water supply is critical for its operations. Traditionally, the water used in mining production was taken from rivers or underground wells. Because droughts have made these water sources dry, mining companies have been forced to invest in costly other means of getting water, for example, by creating seawater desalination plants, which has been costly for them. In fact, according to some estimates, water-related infrastructures already account for about 10 percent of mining capital costs around the world.[2]

Farms also consume massive amounts of water. Agricultural activities use about 80% of all the water that is consumed throughout Chile. Farmers have, for decades, also obtained most of their water from the rivers that are now drying up. To alleviate the problems, farmers have had to invest in sophisticated drip systems that use only a fraction of the water they used to consume. A study by (Roco, Bravo-Ureta, Engler, & Jara-Rojas, 2017) show that the use of climate change adaptive practices, such as irrigation improvements, have a significant and positive effect on

[1] https://www.economist.com/leaders/2019/09/19/the-climate-issue?fsrc=scn/li/te/bl/ed/theclimateissueawarmingworld.

[2] A report by Global Water Intelligence, cited by Reuters, estimates that mining companies spent $11.9 billion on water infrastructure in 2013, up from the $3.4 billion spent in 2009. Reuters' article is available at https://www.reuters.com/article/mining-water-idCNL2N0D40F120130530.

farms' productivity in central Chile. Even more, some large farmers, such as winemakers, have relocated south of the country, where there are still plenty of water supplies.[3]

Of course, relocation, sophisticated irrigation systems, and seawater desalination infrastructures require significant amounts of capital. While wealthier farmers and large mining corporations can easily make these investments, most small farmers and small miners cannot afford the investments needed to adapt to changing climate conditions and are forced to go out of business.

After climate-related disasters make entrepreneurs fail, they have to reinvent themselves and start up again. Several authors have examined the relationship between disasters (both human-induced and natural disasters) and entrepreneurial dynamics. The study of Doern, Williams, & Vorley (2019) provides an excellent systematic literature review on the effects that financial crises (Bishop, 2019), armed conflicts (Kwong, Cheung, Manzoor, & Rashid, 2019), earthquakes (Williams & Shepherd, 2016), volcano eruptions (Muñoz, Kimmitt, Kibler, & Farny, 2019), among other emergencies, have on entrepreneurship. This literature suggests that because of disasters usually inflict several damages to the economy; it can bring the necessity for entrepreneurs to create new ventures (Monllor & Altay, 2016; Pe'er & Vertinsky, 2008). These prospects appear because when established businesses and industries are disrupted and possibly eliminated, it immediately creates the necessity for people to start new ventures as a way to compensate for the loss of their usual source of employment (Shane, 2009; Valdez & Richardson, 2013). It follows from these arguments that our first hypothesis is that extended periods of droughts increase entrepreneurial intention because they generate necessity-driven motives.

[3] https://www.bloomberg.com/features/2020-chile-wine/

The conceptual approach of Monllor & Murphy (2017) suggests that disasters can also be beginning for entrepreneurial opportunities and increases entrepreneurial intentions far from those based on sheer necessity. Moreover, Patzelt & Shepherd (2011) contend that, in the aftermath of a disaster, the novelty in the natural environment can expand the possibility of identifying opportunities for sustainable growth. Anecdotal evidence supports this argument, and many startups are turning water problems into business opportunities. For instance, in Silicon Valley, many companies are offering services such as software to perform analytics on water usage, novel water treatment technology, and solutions to reuse and recycle wastewater. In the case of the agricultural sector, some ventures are developing innovative soil-moisture monitoring technology, and sensors and software to improve farm irrigation.[4] On a smaller scale, with local water sources drying as a result of intensifying droughts and discriminated farm irrigation practices, many villagers in Chile rely on water delivered by truck tankers twice a week.[5] These tankers are small companies that are taking advantage of a very profitable business opportunity. These conceptual elements and anecdotal evidence lend support to our second hypothesis. We hypothesize that the increase in the frequency of drought events enhances the entrepreneurial intention of people pursuing business opportunities.

Certainly, both necessity- and opportunity-based entrepreneurs will launch new ventures in sectors that are not water-intensive. Instead, in the case of necessity-based entrepreneurs, they will probably look to offer new products and services unrelated to water infrastructure. Opportunity driven entrepreneurs, in the pursuit of profit, might look for businesses that address the increasing water needs in their regions, taking advantage of what they know about the difficulties and the opportunities that have appeared after long periods of droughts in their communities (Monllor &

[4] https://techcrunch.com/2015/06/22/turning-water-problems-into-business-opportunities/
[5] https://news.trust.org/item/20190603094543-nn439

Murphy, 2017). In either case, we expect that increases in drought trends will raise the probability of setting up ventures that offer services to other businesses or startups in consumer-oriented segments such as retail, personal services, and restaurant activities. At the same time, we expect a decrease in the rate of new ventures in extractive, water-intensive sectors such as mining, agriculture, and forestry. Our last hypothesis is that the occurrence of droughts increases entrepreneurial intention for necessity driven entrepreneurs in consumer-oriented activities. Meanwhile, droughts will also increase entrepreneurial activity for opportunity-based entrepreneurs in sectors that are more innovative and have high-growth potentials.

Chile provides an especially suitable framework to test hypotheses regarding the effects of climate risk on entrepreneurial dynamics. First, according to data collected by the Global Entrepreneurship Monitor (GEM) in 2019, Chile is the most entrepreneurial country in the world. About 36.7 percent of its adult population is actively engaged in starting or running new businesses (Bosma et al., 2020). Second, in Chile, climate risks are already beginning to materialize. For instance, the country has been suffering numerous cases of droughts, including a drought between 2008-2015 that affected the central and southern areas. And a drought in 2019 that forced the Chilean government to declare an agricultural emergency in three regions in the central part of the country. Moreover, according to the Climate Change Knowledge Portal of the World Bank, ensemble projection models estimate that annual severe drought likelihood for the country will increase by 34% by mid-century and 63% by the end of the century.[6] Consequently, we use Chile as our empirical setting to examine how climate risks, measured by droughts and water scarcity trends, influence early-stage entrepreneurial activity.

[6] https://climateknowledgeportal.worldbank.org/country/chile/vulnerability

Our results indicate that droughts are positively related to individual entrepreneurial efforts in Chile for both necessity- and opportunity-based entrepreneurs. These results are consistent with the hypothesis that climate risks create new entrepreneurial opportunities for the people affected by climate change. Furthermore, we find that droughts increase the probability that both necessity- and opportunity-driven entrepreneurs will start up ventures related to business services and consumer-oriented activities as oppose to traditional agriculture and extractive businesses. Overall, the results are consistent with our intuition that climate change problems have a meaningful impact on both necessity- and opportunity-driven entrepreneurial efforts. To the best of our knowledge, this investigation is the first study that provides direct empirical evidence on how climate risks, measured by drought trends, influence entrepreneurial decisions. We are also the first to combine a widely used database on entrepreneurial research, the Global Entrepreneurship Monitoring (GEM) (Bosma, 2013), with a long historical panel data set with climate variables (in particular, precipitation and drought data) mostly used in climate studies. After this data integration, we are able to measure and assess a specific climate risk on entrepreneurial activity.

The remainder of the paper is organized as follows. Section 2 describes the dataset and explains the empirical designs and methods. Section 3 presents the empirical results. Section 4 discusses the empirical results. The last section provides concluding remarks.

2. Materials and Methods

2.1 Drought trend measures

Our drought data comes from the Palmer Drought Severity Index (PDSI) (Dai, Trenberth, & Qian, 2004), a metric that is often used in climate studies.[7] More recently, this data was used in a

[7] The data is available for download at https://climatedataguide.ucar.edu/climate-data/palmer-drought-severity-index-pdsi.

finance paper by Hong, Li, & Xu (2019). The index is a measurement of drought intensity based on a model developed by (Palmer, 1965) that considered the supply and demand of soil moisture. The index includes not only the quantity of moisture in the soil, but it also takes into account factors like evapotranspiration and recharge rates. The index measures droughts on a scale from -10 (dry) to 10 (wet).[8] For this paper, we use monthly PDSI over land areas along Chile computed using observed or modeled monthly surface air temperature and precipitation. The PDSI data starts from January 1900 to December 2014. The PDSI dataset is structured in longitude and latitude coordinates, with a spatial resolution of the raster dataset of 2.5 x 2.5 cells. We extract each Chilean region's PDSI based on the geographic coordinates of that region.

Figure 1 plots the time series of monthly PDSI values for Chile in addition to the fitted trend line. The figure shows that Chile, on average across all its regions, has been affected by worsening droughts over time. Anecdotal evidence confirms that Chile did experience the intensified droughts revealed by this PDSI trend. For instance, in 2015 and 2019, the government has declared agricultural emergencies in three regions in the central part of the country and announced a series of relief measures for farmers, including the provision of drinking water and medicine for animals.[9] Data on land prices have also shown the effects of droughts as relative wetter southern regions of Chile have experienced significant increases in price over the past five years as large farmers are migrating to the south part of the country.[10]

[INSERT FIGURE 1 ABOUT HERE]

[8] Climate studies consider a grade of −4 and below as extreme drought conditions, −3.9 to −3 is severe drought, −2.9 to −2 is moderate drought, −1.9 to 1.9 is mid-range (regular), 2 to 2.9 is moderately moist, 3 to 3.9 is very humid, and 4 and above is extremely wet.

[9] https://www.reuters.com/article/us-chile-environment/chiles-president-announces-water-crisis-team-amid-intense-drought-idUSKCN1VQ2SU.

[10] https://www.bloomberg.com/features/2020-chile-wine/

Climate change studies indicate that global warming has generated the conditions for increasing periods of droughts over time. We follow Hong et al. (2019) and model trends in droughts across the 15 Chilean regions using a simple autoregressive AR(1) model for PDSI, expanded with a deterministic time trend t, using the following specification:

$$PDSI_{j,t} = a_j + b_j t + c_j PDSI_{j,t-1} + \epsilon_{j,t}. \quad (1)$$

This model contains an intercept term (a_j), a coefficient for the trend term (b_j), and the autoregressive term (c_j). The trend coefficient (b_j) is our parameter of interest and give us the drought time trend in region j. This time trend should capture the long-run effect of climate change on the region's drought vulnerability (Hong et al., 2019). We estimated the trend term (b_j) for each region on a rolling basis using all PDSI data from January 1900 up to December of year t. We will denote the estimated coefficient as *Drought Trend*$_{j,t}$. Finally, we use these time trends to proxy for drought vulnerability (i.e., the more negative the time trends in PDSI are, the more vulnerable are the regions to drought).[11]

Table 1 reports the results from Equation (1). For every region, the constant, lagged PDSI, and trend estimates we shown are the averages of the estimates over all the months from the rolling estimation between 2006 and 2014. As demonstrated, there is significant heterogeneity in time trends of droughts across regions. For instance, central and southern areas of the country have experienced very negative time trends in drought (i.e., are the most vulnerable to drought), whereas northern regions have positive trends.

[INSERT TABLE 1 ABOUT HERE]

[11] Later in the paper, to interpret regression coefficients more intuitively, we use the variable *DroughtVulnerability* instead of *DroughtTrends*. *DroughtVulnerability* is *DroughtTrend* multiply by -1.

2.2 *The Early-Stage Entrepreneurial Activity Index*

Our source of entrepreneurial activity data for each Chilean region comes from the Global Entrepreneurship Monitor (GEM) surveys. The GEM's methodology includes the Adult Population Survey (APS), which covers a representative sample of the population in each participant region of Chile (Mandakovic & Serey, 2016). We use data from 9 years between 2006 and 2014 to evaluate the evolution of entrepreneurship dynamics. Our analysis covers responses from 35,886 individuals. We choose our sample period so that the GEM survey was performed in each region for every year that we include in our analysis. The GEM asks participants to share their reason to take part in early-stage entrepreneurial activities. These motivations are classified into two categories: Necessity and opportunity-based entrepreneurial activity. We test our hypotheses using these two motivational variables as dependent variables. A necessity-based entrepreneur is a respondent that agreed with the following statement: "I am in this startup because I have no better choices for work." Meanwhile, opportunity-based entrepreneur comprises individuals who voluntarily create a new venture to pursue perceived business opportunities (Amorós, Ciravegna, Mandakovic, & Stenholm, 2017; Amorós, Poblete, & Mandakovic, 2019). An opportunity-based entrepreneur is a respondent that agreed with the following statement: "I am in this startup to take advantage of a business opportunity." We created two dichotomic variables for each category that takes the value of 1 if they agree with one of the previous statement, and zero otherwise.

Table 2 presents descriptive statistics for our dependent and independent variables across all Chilean regions. We define all variables in Table A1 in Appendix A. The average drought vulnerability for the period 2006 – 2014 is 10.284 bps, which indicates that the country has become driest across its regions. Meanwhile, the average total entrepreneurial activity in Chile between

2006 and 2014 is 20.7 percent. On average, 4.9 percent of the respondent declared to be a necessity-based entrepreneur, and 15.3 percent affirmed to be an opportunity-based entrepreneur. Table 2 also reports summary statistics for other key variables we use in this study. About 32.2 percent of respondents have some fear of failure, 42.4 percent known an entrepreneur, 60.5 percent have a high degree of confidence in her or his skills for business, 6.6 percent have had a past entrepreneurial failure. Meanwhile, the average age is 43 years old, about 54.7 percent of the sample corresponds to females, and the average respondent has completed secondary education. Table A2 in Appendix B shows the correlation coefficients among dependent and independent variables.

[INSERT TABLE 2 ABOUT HERE]

2.3 *Empirical Models*

We use a multivariate setting to examine the effect of drought vulnerability on the likelihood of being an early-stage entrepreneur by estimating the following logistic regression specification:

$$\Pr\left[Entrepreneur_{i,j,t} = 1\right] = \alpha + \beta * DroughtVulnerability_{j,t} + \gamma' X_{i,j,t} + R_j + \epsilon_{i,} \quad (2)$$

where the dependent variable $\Pr\left[Entrepreneur_{i,j,t} = 1\right]$ is the probability that individual i is an early-stage entrepreneur in region j at year t. We use the indicator variable Early-Stage Entrepreneurial Activity (TEA) from GEM to identify whether an individual has been engaged in the creation of a new firm. As we mentioned before, GEM further classifies individuals involved in TEA according to their motivations to pursue entrepreneurial activities. These two categories are necessity- and opportunity-based entrepreneurship. We test our hypotheses using the general TEA and TEA from these two motivational variables as dependent variables.

The variable of interest in Equation (2) is *DroughtVulnerability* for region j at year t. If climate risk (water scarcity) affects entrepreneurial efforts, we expect the beta coefficient on Drought

Vulnerability to be positive. The vector X_i contains control variables. We control for other individual characteristics that are reported in the literature as relevant for the probability of being an entrepreneur. We include the following four attitudinal variables from the GEM database that prior research links to entrepreneurial behaviors (e.g., Amorós et al., 2017, 2019; Guerrero, Amorós, & Urbano, 2019; among others): Know entrepreneur, a proxy for the use of social capital, is a dummy variable that equals one if the answer is yes to the question "Do you know someone personally who started a business in the past two years?" and zero otherwise. Second, self-efficacy, which proxies for entrepreneurs' confidence in their entrepreneurial expertise, is a dummy variable that equals one if the answer is yes to the question "Do you have the knowledge, skill, and experience required to start a new business?" and zero otherwise. Third, fear of failure is a dummy variable that equals one if the answer is yes to the question "Would fear of failure would prevent you from starting a business?" and zero otherwise. Finally, past failure is a dummy variable that equals one if the answer is yes to the question "Have you, in the past 12 months, sold, shut down, discontinued, or quit a business you owned and managed, any form of self-employment, or selling goods or services to anyone?" We also include individual demographic variables used as controls obtained from the GEM database and include age, gender, and level of education (0 = none, 1= some secondary, 2 = secondary degree, 3 = postsecondary, and 4 = graduate experience).

To test our last hypothesis, we split the sample into different industrial sectors of new firms. We also take this information from the GEM database that classifies entrepreneurship activities into four broad categories: extractive, manufacturing, business services, and consumer-oriented activities. The extractive sector includes agriculture, forestry, fishing, and mining. The transformative industry covers construction, manufacturing, transportation, communication, utilities, and wholesale. The business services sector comprises finance, insurance, real estate, and

other business services. Finally, the consumer-oriented industry includes retail, motor vehicles, lodging, restaurants, personal services, health, education, social services, and recreational services.

3. Results

This section analyzes the empirical results for the effects of drought vulnerability on the likelihood of being an early-stage entrepreneur. We perform logistics models with robust standards errors to test this relation.

Table 3 shows the logistic regression results when we regress the probability of being an entrepreneur on drought vulnerability and the control variables and region fixed-effects. Column 1 reports the results for total entrepreneurship. Column 2 reports the results for necessity-based entrepreneurship. Column 3 reports the results for opportunity-based entrepreneurship. For each model, we report both estimated coefficients and marginal effects. Estimated results across all models show that drought vulnerability is statistically significant and positively influence the probability of being an early-stage entrepreneur. Whereas there is a positive effect for both necessity and opportunity-based entrepreneur (columns 2 and 3, respectively), the magnitude of the coefficient is more substantial for opportunity-based entrepreneurship. This result is consistent with the arguments that natural disasters also create opportunities for innovative and potential high-growth new venture formation. Overall, our results support our hypothesis that climate risk, measured by the trend in drought vulnerability, influences entrepreneurial dynamics, and enhances the likelihood of becoming an entrepreneur.

Several control variables in Table 3 across all models show meaningful results that respond to expectations. The probability of becoming an entrepreneur is negatively related to fear of failure and positively associate with knowing an entrepreneur, the perception of self-efficacy, and age (at a decreasing rate). As expected, the variable education is negatively related to the likelihood of

becoming a necessity-based entrepreneur and positively related to the probability of becoming an opportunity based-based entrepreneur. Finally, the results for gender show that being female is positively related to the probability of becoming a necessity-based entrepreneur and negatively related to the likelihood of becoming an opportunity based-based entrepreneur.

[INSERT TABLE 3 ABOUT HERE]

Next, we examine the effects of climate risk on entrepreneurial activities across broad industry classifications. We separate our early-stage entrepreneurial activity (opportunity- and necessity-based entrepreneurial activity) into four different industrial sectors of new firms: extractive, manufacturing, business services, and consumer-oriented activities.

In Table 4, we show the results (marginal effects) for necessity-based entrepreneurs when we split the sample into the four economic sectors. Columns 3 and 4 of Table 4 show that the increase in drought vulnerability has a positive and statistically significant (at the 1% level) influence on the likelihood to become a necessity-based entrepreneur in both the business services and consumer-oriented sectors. However, the magnitude of the coefficient is more economically significant for the consumer-oriented industry. In other words, during periods of increased droughts, the probability of becoming a necessity-based entrepreneur increases significantly for business related to retail and other consumer-oriented activities. The reason is that entrepreneurs have to reinvent themselves from traditional agriculture, mining, and other water-intensive extractive businesses.

Consequently, these results support the hypothesis that necessity-based and opportunity-based entrepreneurs will lunch new ventures in sectors that are not water-intensive. Also, as previously discussed, early-stage entrepreneurs lack the resources to relocate or make the technology transformations needed to adapt to changing climate conditions and are forced to look for new

ways to acquire a livelihood. Accordingly, entrepreneurs turn to retail, restaurants, and similar consumer-oriented services for money, pushed by the consequences of extended periods of droughts that have disrupted their usual source of income. These results are consistent with the arguments of Monllor & Altay, 2016; Pe'er & Vertinsky (2008) who state that natural disasters disrupt and can even eliminate established businesses. Thus, these events create the necessity for individuals to start new entrepreneurial ventures.

[INSERT TABLE 4 ABOUT HERE]

Table 5 shows the results (marginal effects) when we examine the influences of drought vulnerability trends on opportunity-based entrepreneurial activity by the industrial sector. In addition to the significant impact of droughts on startups formations in the business services and consumer-oriented industries, in the case of opportunity-based entrepreneurs, the effect is also positive and statistically significant (at the 1% level) for the likelihood to engage in opportunity-based entrepreneurship in the transformative sectors. This result seems to suggest that extended droughts not only influence the creation of opportunities for new venture formation in the services and retail industries but also affect entrepreneurial activity in more sophisticated sectors such as the ones included in the transformative sector (construction, manufacturing, transportation, communication, utilities, and wholesale). These results are consistent with Monllor & Murphy (2017) and Patzelt & Shepherd (2011), who argue that the circumstances created by natural disasters can be a source of new entrepreneurial opportunities, afar from those because of pure necessity, and emergencies can increase the chances of acknowledging opportunities for long-lasting businesses.

[INSERT TABLE 5 ABOUT HERE]

4. Discussion

We now discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses.

Despite the increasing concerns regarding the economic effects of climate change risks, individual entrepreneurial efforts have received scant attention in entrepreneurship research compared to the growing climate economic and climate finance literature. In this article, we examine how entrepreneurs adapt to climate change by examining the influences of drought vulnerability trends on early-stage entrepreneurial activity in Chile.

We believe that droughts represent a proper climate setting to test the hypothesis concerning climate risk and entrepreneurship. First, climate studies suggest that climate change might amplify the occurrence of natural disasters such as hurricanes, storms, floods, and droughts. Among these natural disasters, drought is considered one of the most harmful for businesses in Chile. Second, climate change has already started affecting the occurrence of extended periods of drought in central Chile. So it is not a distant risk for the country.

Water problems increase the number of people who might need to engage in new entrepreneurial ventures to meet their basic needs. Therefore, our results regarding the positive effects of droughts on necessity-based entrepreneurship are expected. Perhaps the most surprising finding is that droughts have an even more economically significant impact on opportunity-based entrepreneurship. Opportunity-based entrepreneurs engage in new ventures looking for advancement, financial gain, innovation, and personal fulfillment (Cullen, Johnson, & Parboteeah, 2014; McMullen, Bagby, & Palich, 2008; Reynolds et al., 2005). Opportunity based entrepreneurship is, thus, generally related to new activities that could generate new jobs and increase productivity in the economy (Stenholm, Acs, & Wuebker, 2013). One explanation for this

unexpected result is provided by Monllor & Murphy (2017). These authors contend that when a group of people regularly endure natural disasters, as we demonstrate in this paper measuring repeated and extended periods of droughts, they obtain considerable knowledge of the issues and opportunities that appear after such emergencies. The knowledge they acquire can be from previous markets that succeeded and were unsuccessful after the disaster, methods of how those markets have been served, and experience of client problems as a consequence of the disruption, all of which Shane (2000) argues, influence the individual discovery of opportunities. The more these people learn about these issues, the better knowledge they will have when starting with a new product or services that offer better ways of approaching clients' problems and succeeding in solving them. Thus, people living in areas with regular droughts are expected to be more able to see opportunities as they have the knowledge about issues caused by disasters, and ways of solving the problems when trying to serve their markets.

We believe our results have important policy implications. From a practical perspective, our results could be useful for the design of public policies and strategies to mitigate the impacts of climate risks. For instance, in addition to short-term relief policies such as the provision of drinking water and medicine for animals, we think policymakers should also provide funding and training for the distressed people, so they can take advantage of the opportunities that the droughts might present to create new and sustainable ventures.

This study offers novel insights and opens several alternatives for research in the new area of climate entrepreneurship. Future lines of research should continue with an in-depth study of particular industries across countries that are affected at different degrees by droughts. Climate change will increase the frequency of extended periods of drought in some countries such as Peru and Chile. Meanwhile, other countries like New Zealand and northern Australia could become

warmer and wetter and benefit from more rain to some of their regions. This distinction offers the perfect empirical setting to test the effect of climate change on entrepreneurial activity across countries. Subsequent studies could also further investigate the influences of other climate risks such as increasing temperatures, wildfires, and rising sea-levels on entrepreneurial efforts.

5. Conclusions

This study examines some essential features of climate risk and entrepreneurial activities that have not been previously analyzed in the literature. In particular, we study the effects of droughts on necessity- and opportunity-based individual entrepreneurial efforts in Chile. Using an extensive database of 35 thousand individuals between 2006 and 2014, and a widely used metric in climate studies that capture drought intensity with a high degree of spatial resolution, we show that increases in droughts are positively associated with the likelihood that an individual will engage in entrepreneurial activity. Furthermore, we show that this effect is positive for both necessity- and opportunity-based entrepreneurship, with the magnitude of the result being larger for opportunity-based entrepreneurial efforts.

We also examine the industry profiles of early-stage entrepreneurs and their relationship to regional drought vulnerability trends. We show that droughts increase the probability that an individual will start up a new venture in business and consumer-oriented service activities as they have to reinvent themselves from extractive, water-intensive businesses.

Overall, this paper identifies another role that climate change plays in the economy. More importantly, this article sheds light on the degree to which climate change risks have a meaningful impact on opportunity and necessity-driven entrepreneurial efforts in an emerging market country.

Appendix A

Table A1 defines dependent, independent, and control variables used in this study.

Table A1. Variable definitions

Variable name	Definition
General entrepreneur	A dummy variable that equals one if the person is involved in an early-stage entrepreneurial activity, and zero otherwise.
Necessity-based entrepreneur	A dummy variable that equals one if the person is involved in early-stage entrepreneurial activity for necessity reasons, and zero otherwise.
Opportunity-based entrepreneur	A dummy variable that equals one if the person is involved in an early-stage entrepreneurial activity motivated by business opportunities, and zero otherwise.
Drought trend	The estimated measure of the time trend terms (b_i) in the following AR(1) model for PDSI, augmented with a deterministic time trend t: $$PDSI_{it} = a_i + b_i t + c_i PDSI_{it-1} + \epsilon_{jt}.$$ We multiply this time trend estimate (b_i) by -1 to ease the interpretation of results. After this transformation, the higher the number for the drought trend variable, the most the vulnerability to droughts. PDSI stands for the Palmer Drought Severity Index (see, Dai et al., 2004 for more details).
Drought vulnerability	Drought trend * (-1).
Fear of failure	A dummy variable that proxies for fear of failure when undertaking new business venture activities and equals one if the answer is yes to the question "Would fear of failure would prevent you from starting a business?" and zero otherwise.
Know entrepreneur	A dummy variable that proxies for the use of social capital (i.e., knowing other entrepreneurs) and equals one if the answer is yes to the question "Do you know someone personally who started a business in the past 2 years?" and zero otherwise.
Self-efficacy	A dummy variable that proxies for the individual's perceived self-efficacy in entrepreneurial efforts and equals one if the answer is yes to the question "Do you have the knowledge, skill, and experience required to start a new business?" and zero otherwise.
Past failure	A dummy variable that measures past failure when the individual has discontinued a business and equals one when the answer is yes to the question "Have you, in the past 12 months, sold, shut down, discontinued, or quit a business you owned and managed, any form of self-employment, or selling goods or services to anyone?" and zero otherwise.
Age	Age of the individual in years.
Gender	A dummy variable that equals one for female, and zero otherwise.
Education	Level of education related to the educational attainment, where, 0 = none, 1= some secondary, 2 = secondary degree, 3 = postsecondary, and 4 = graduate experience).

Appendix B

Table A1 presents the correlation matrix for dependent, independent, and control variables used in this study.

Table A2. **Correlation matrix**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Drought Vulnerability	1.00										
(2) General Entrepreneur	-0.01	1.00									
(3) Opportunity-Based Entrepreneur	0.00	0.44	1.00								
(4) Necessity-Based Entrepreneur	-0.01	0.83	-0.10	1.00							
(5) Fear of Failure	-0.02	-0.13	-0.02	-0.13	1.00						
(6) Know Entrepreneur	0.01	0.22	0.06	0.21	-0.09	1.00					
(7) Self-Efficacy	0.00	0.26	0.10	0.23	-0.23	0.22	1.00				
(8) Past Failure	0.00	0.09	0.06	0.07	-0.03	0.08	0.12	1.00			
(9) Age	-0.01	-0.09	0.01	-0.10	0.09	-0.13	-0.03	0.01	1.00		
(10) Gender	0.00	-0.07	0.05	-0.11	0.12	-0.10	-0.13	-0.02	0.07	1.00	
(11) Education	0.00	0.09	-0.05	0.12	-0.09	0.18	0.15	0.01	-0.26	-0.12	1.00

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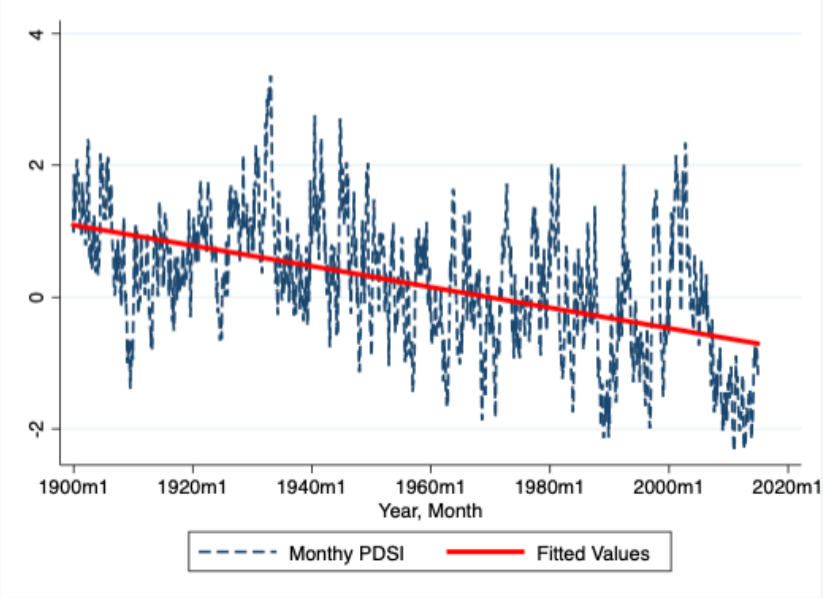

Figure 1. Historical PDSI for Chile. This figure plots the time series of monthly PDSI values for Chile. The sample period runs from January 1900 to December 2014. The PDSI value is shown on the vertical axis. The horizontal axis is time. The solid red line is the linear trend line through the time series.

Table 1. Summary Statistics of PDSI Trend Estimates over Time, Region by Region.

Region	Regional Capital	Intercept	Trend (bps)	Lagged PDSI
XV Region	Arica	0.565	1.815	0.854
I Region	Iquique	1.076	6.937	0.841
II Region	Antofagasta	0.922	2.657	0.818
III Region	Copiapó	0.166	-16.072	0.838
IV Region	Coquimbo	0.223	-13.601	0.892
V Region	Valparaíso	0.608	-8.844	0.917
Metropolitan Region	Santiago	0.396	-9.168	0.910
VI Region	Rancagua	0.264	-9.126	0.897
VII Region	Talca	0.273	-8.835	0.897
VIII Region	Concepción	0.077	-9.818	0.886
IX Region	Temuco	-0.045	-13.083	0.886
XIV Region	Valdivia	-0.037	-12.348	0.881
X Region	Puerto Montt	-0.283	-11.872	0.889
XI Region	Aisén	-0.133	-15.816	0.878
XII Region	Punta Arenas	0.387	-26.991	0.895

Note. This table reports summary statistics for the intercept, trend coefficient (expressed in basis points), and lag coefficient in the following autoregressive AR(1) model: $PDSI_{it} = a_i + b_i t + c_i PDSI_{it-1} + \epsilon_{jt}$. Regional-level data on droughts for Chile are taken from the Palmer Drought Severity Index (PDSI) retrieved from the Climate Data Guide. For a detailed definition of PDSI, please refer to Dai et al. (2004).

Table 2. Summary Statistics, All Regions

Variable	N	Mean	SD	Min	Max
Drought Vulnerability (bps)*	35886	10.284	9.448	-7.145	28.161
General Entrepreneur (1=Yes, 0=No)	35886	0.207	0.405	0.000	1.000
Necessity-Based Entrepreneur (1=Yes, 0=No)	35886	0.049	0.216	0.000	1.000
Opportunity-Based Entrepreneur (1=Yes, 0=No)	35886	0.153	0.360	0.000	1.000
Fear of Failure (1=Yes, 0=No)	35886	0.322	0.467	0.000	1.000
Know Entrepreneur (1=Yes, 0=No)	35886	0.424	0.506	0.000	4.000
Self-Efficacy (1=Yes, 0=No)	35886	0.605	0.489	0.000	1.000
Past Failure (1=Yes, 0=No)	35886	0.066	0.248	0.000	1.000
Age	35886	42.780	16.422	18.000	99.000
Gender (1=Female, 0=Male)	35886	0.547	0.498	0.000	1.000
Education (1= None, 2= Some secondary, 3=Secondary, 4=Post-Secondary, 5=Graduate)	35886	3.138	1.034	1.000	5.000

Note. This table reports summary statistics for the dependent, independent, and control variables used in this study. The sample is comprised of 38,886 individuals from 16 regions of Chile between 2005 and 2014. Individual-level data is taken from the Global Entrepreneurship Monitor. Regional-level data on droughts is taken from the Palmer Drought Severity Index (PDSI) retrieved from the Climate Data Guide. See Appendix A for variable definitions. * Drought Vulnerability = Drought Trend *(-1).

Table 3. The Effect of Drought Vulnerability Trends on The Probability of Becoming an Entrepreneur

Dep. Variable: Prob (Entrepreneur = 1)	**Total (1)**		**Necessity (2)**		**Opportunity (3)**	
	Raw	Margin	Raw	Margin	Raw	Margin
Drought Vulnerability	15.0634***	2.0155***	4.4537**	0.1602**	18.2171***	1.6975***
	(11.9524)	(12.0127)	(2.0323)	(2.0317)	(12.8393)	(12.9039)
Control Variables						
Fear of Failure	-0.4124***	-0.0552***	-0.0849	-0.0031	-0.4849***	-0.0452***
	(12.1344)	(12.2007)	(1.4595)	(1.4595)	(12.2890)	(12.3806)
Know Entrepreneur	0.8158***	0.1092***	0.4041***	0.0145***	0.8459***	0.0788***
	(28.6408)	(28.7004)	(8.1220)	(8.1541)	(26.5888)	(26.3230)
Self-Efficacy	1.2637***	0.1691***	1.0321***	0.0371***	1.2385***	0.1154***
	(34.2489)	(36.3433)	(15.1526)	(16.2165)	(28.4426)	(30.0878)
Past Failure	0.4380***	0.0586***	0.5631***	0.0202***	0.2778***	0.0259***
	(8.7907)	(8.7587)	(7.3209)	(7.2583)	(5.0740)	(5.0612)
Age	0.1051***	0.0141***	0.1137***	0.0041***	0.0953***	0.0089***
	(17.8183)	(18.3328)	(11.2078)	(11.5330)	(13.6791)	(14.1708)
Age Squared	-0.0013***	-0.0002***	-0.0013***	-0.0000***	-0.0013***	-0.0001***
	(19.3741)	(20.0837)	(11.4067)	(11.7751)	(15.5347)	(16.2821)
Gender	-0.1328***	-0.0178***	0.4950***	0.0178***	-0.3595***	-0.0335***
	(4.6757)	(4.6768)	(9.2971)	(9.4651)	(11.3021)	(11.3260)
Education	0.0173	0.0023	-0.3261***	-0.0117***	0.1763***	0.0164***
	(1.1550)	(1.1549)	(13.2526)	(13.6226)	(10.2085)	(10.2333)
Constant	-3.1175***		-5.2859***		-3.2866***	
	(19.6805)		(18.5247)		(18.1796)	
Observations	35886		35886		35886	
Pseudo R2	0.1328		0.0690		0.1435	

Note. This table presents the parameter estimates from logistic regressions for the likelihood of becoming an early-stage entrepreneur (a person that is actively engaged in starting or running new businesses). The dependent variable in Column 1 is the probability of being an entrepreneur in general. The dependent variable in Column 2 is the probability of being a necessity-driven entrepreneur. The dependent variable in Column 3 is the probability of being an opportunity-driven entrepreneur. The key independent variable is the drought vulnerability in the region during the year. All control variables are defined in Appendix A. t values (in parentheses) are computed with robust standard errors. ***, **, and * indicate that the coefficient is significantly different from zero at the 1%, 5%, and 10% levels, respectively.

Table 4. The Effect of Drought Vulnerability Trends on The Probability of Becoming a Necessity-Based Entrepreneur, Categorized by Economic Sector.

Dep. Variable: Prob (Nec. Entrepreneur = 1)	**Extractive (1)**	**Transformation (2)**	**Business (3)**	**Consumer (4)**
	Margin	Margin	Margin	Margin
Drought Vulnerability	0.0037	0.0652*	0.0598***	0.2339***
	(0.4073)	(1.9299)	(2.9114)	(4.1565)
Control Variables				
Fear of Failure	-0.0000	-0.0009	0.0002	-0.0020
	(0.0270)	(0.9344)	(0.2976)	(1.3098)
Know Entrepreneur	-0.0002	0.0033***	0.0019***	0.0073***
	(0.8976)	(4.1370)	(3.6677)	(5.6867)
Self-Efficacy	0.0007***	0.0061***	0.0028***	0.0222***
	(2.5791)	(5.8760)	(4.2127)	(13.2527)
Past Failure	0.0003	0.0025**	0.0017**	0.0126***
	(0.8605)	(1.9770)	(2.3892)	(6.3228)
Age	0.0000	0.0014***	0.0003***	0.0018***
	(1.0737)	(8.5528)	(2.9996)	(7.2188)
Age Squared	-0.0000	-0.0000***	-0.0000***	-0.0000***
	(0.8783)	(8.4866)	(3.3023)	(7.6627)
Gender	-0.0004*	-0.0009	-0.0004	0.0184***
	(1.7917)	(1.0793)	(0.8968)	(12.8743)
Education	0.0000	-0.0030***	0.0009***	-0.0078***
	(0.0608)	(8.1121)	(3.8384)	(12.5165)
Observations	28946	35886	35736	35886
Adjusted R2	0.08234	0.0591	0.0564	0.0771

Note. This table presents the parameter estimates from logistic regressions for the likelihood of becoming an early-stage necessity-based entrepreneur (a person that is actively engaged in starting or running new businesses motivated by necessity). Each column represents four different industrial sectors of new firms: extractive (column 1), manufacturing (column 2), business services (column 3), and consumer-oriented activities (column 4). The key independent variable is the drought vulnerability in the region during the year. All control variables are defined in Appendix A. t values (in parentheses) are computed with robust standard errors. ***, **, and * indicate that the coefficient is significantly different from zero at the 1%, 5%, and 10% levels, respectively.

Table 5. The Effect of Drought Vulnerability Trends on The Probability of Becoming an Opportunity-Based Entrepreneur, Categorized by Economic Sector.

Dep. Variable: Prob (Opp. Entrepreneur = 1)	**Extractive (1)**	**Transformation (2)**	**Business (3)**	**Consumer (4)**
	Margin	Margin	Margin	Margin
Drought Vulnerability	0.0180	0.3778***	0.3163***	1.2655***
	(1.1501)	(6.7300)	(9.7643)	(13.5595)
Control Variables				
Fear of Failure	-0.0004	-0.0102***	-0.0034***	-0.0238***
	(0.9650)	(6.0527)	(3.6189)	(9.0787)
Know Entrepreneur	0.0019***	0.0136***	0.0086***	0.0366***
	(5.3120)	(10.7961)	(10.5547)	(17.7579)
Self-Efficacy	0.0028***	0.0249***	0.0106***	0.0596***
	(5.3087)	(13.5349)	(9.4836)	(21.4499)
Past Failure	0.0015***	0.0029	0.0012	0.0108***
	(2.6016)	(1.3631)	(0.9899)	(3.0791)
Age	0.0001	0.0024***	0.0009***	0.0040***
	(1.3620)	(8.6154)	(5.3254)	(9.0500)
Age Squared	-0.0000	-0.0000***	-0.0000***	-0.0001***
	(0.9235)	(8.9133)	(6.5275)	(11.1205)
Gender	-0.0024***	-0.0154***	-0.0097***	0.0076***
	(5.4960)	(11.5300)	(11.0114)	(3.6661)
Education	0.0010***	-0.0000	0.0065***	0.0020*
	(4.3702)	(0.0481)	(13.9132)	(1.7997)
Observations	35886	35886	35886	35886
Adjusted R2	0.0987	0.0919	0.1450	0.1018

Note. This table presents the parameter estimates from logistic regressions for the likelihood of becoming an early-stage opportunity-based entrepreneur (a person that is actively engaged in starting or running new businesses motivated by opportunity). Each column represents four different industrial sectors of new firms: extractive (column 1), manufacturing (column 2), business services (column 3), and consumer-oriented activities (column 4). The key independent variable is the drought vulnerability in the region during the year. All control variables are defined in Appendix A. t values (in parentheses) are computed with robust standard errors. ***, **, and * indicate that the coefficient is significantly different from zero at the 1%, 5%, and 10% levels, respectively.