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Climate Risk and Access to Credit: Evidence from Colombian Potato Growers

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Climate Risk and Access to Credit: Evidence from Colombian Potato Growers

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Abstract

We study both the ex post and ex ante effects of climate risk on credit access for small producers of potato in Colombia. First, we explore the ex post effects that come after a drought, a climate shock that affects the production value of the crop. Second, we investigate the ex ante effects through the uncertainty surrounding future climate conditions, using rainfall variability as a proxy for that uncertainty. Finally, we analyze how these two effects interact to influence farmers' use of credit as a coping mechanism for climate risk. We show that credit access (amount disbursed and number of borrowers) increases after adverse weather shocks. However, this is only true under conditions of low rainfall variability and for credits backed by a public-funded guarantee system. Moreover, we find that rainfall variability decreases disbursements of loans with private guarantees. These results suggest that risk exposure is a relevant constraint to credit access and highlight the potential effectiveness of public guarantees in mitigating these risks.

JEL Classification: G21, O13, O54, Q18, Q54
Keywords: Agriculture, credit, climate shocks, developing countries, Colombia

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Riesgo Climático y Acceso al Crédito: Evidencia para Productores de Papa en Colombia

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Resumen

Evaluamos los efectos ex post y ex ante del riesgo climático sobre el acceso al crédito para los pequeños productores de papa en Colombia. En primer lugar, exploramos los efectos ex post que se producen después de una sequía, un choque climático que afecta el valor de la producción de este cultivo. En segundo lugar, analizamos los efectos ex ante a través de la incertidumbre en torno a las condiciones climáticas futuras, utilizando la variabilidad de en la precipitación como indicador. Por último, analizamos cómo estos dos efectos interactúan para influir en el acceso al crédito por parte de los agricultores como mecanismo de enfrentamiento al riesgo climático. Mostramos que el acceso al crédito (i.e., montos desembolsados y número de prestatarios) aumenta con la duración de los periodos de sequía. Sin embargo, esto solo es cierto en condiciones de baja variabilidad de las precipitaciones y para créditos respaldados bajo un sistema de garantías públicas (Fondo Nacional de Garantías). Además, encontramos que la variabilidad de las precipitaciones está asociada a menores desembolsos de préstamos que no están cubiertos por el Fondo. Estos resultados sugieren que la exposición al riesgo climático es una restricción relevante para el acceso al crédito y resaltan la posible efectividad de las garantías públicas para mitigarlos.

Clasificación JEL: G21, O13, O54, Q18, Q54
Palabras clave: Agricultura, crédito, clima, choques climáticos, países en desarrollo, Colombia.

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1 Introduction

Households in developing countries experience high income volatility due to productivity and price shocks. This is particularly relevant for agricultural households, where climate variability poses significant risks. Several studies present evidence that credit constraints hinder these households' ability to smooth consumption after negative income shocks (Jacoby and Skoufias, 1997; Rosenzweig and Wolpin, 1993). At the same time, income uncertainty can increase borrowers' risk and intensify credit constraints. Understanding this interplay between income risk and credit constraints is crucial for understanding the welfare effects of risk in developing countries.

In this paper, we examine the effects of income risk, induced by climate variability, on access to formal credit among small potato growers in Colombia. First, we explore the ex post effects that come after negative climate shocks. Second, we investigate the ex ante effects through the uncertainty surrounding future climate realizations. Finally, we analyze how these two effects interact to influence farmers' use of credit as a coping mechanism for climate risk. We conduct our study on potato growers because is a non-perennial crop, driving them to make production decisions periodically, according to the changing conditions of weather, finances, and trade. Additionally, most of the production takes place on small, rain-fed plots, leaving farmers highly susceptible to productivity shocks caused by water shortages (Barrios-Perez et al., 2023), and a vast majority of growers lack of formal insurance schemes to cope with these events.

The ex post effects of climate risk on credit access can manifest in two distinct ways. On one hand, farmers may increase their demand for credit to smooth consumption after temporary and unexpected climate shocks (Morduch, 1995; Rosenzweig and Wolpin, 1993; Fafchamps and Lund, 2003; Udry, 1990). On the other hand, these shocks can deteriorate credit history and repayment capacity observed by financial intermediaries, thus limiting credit supply for affected farmers (de Roux, 2021). The overall effect of these potential supply and demand movements on access to credit is, therefore, ambiguous.

Additionally, climate risk can have ex ante effects on credit access due to the uncertainty about future income realizations for farmers. On the one hand, high exposure to risk can restrict the demand for credit among risk-averse farmers. This happens because due to information asymmetries, lenders transfer most of the risk in credit contracts to borrowers through collateral requirements, loan disbursement conditional on repayment history, and costly legal recovery processes. This may dissuade farmers from seeking credit when faced with high levels of uncertainty about future income (Boucher et al., 2008, 2009). Conversely, financial intermediaries may reduce the supply of credit in response to increased debtor risk due to higher income uncertainty. The overall effect of these potential supply and demand movements, in the context of greater risk exposure, results in a reduction in access to credit.

We combine the official registries of public-funded loan disbursements from commercial banks to potato growers in Colombia with climate data to estimate the effects of rainfall shocks and rainfall uncertainty on credit access at the municipality level. Based on these data, we propose two measures of climate risk to distinguish between its ex ante and ex post effects. The first measure is the length of droughts during the last crop cycle, calculated as the maximum number of consecutive days with less than 1mm of rainfall in a municipality during the harvest quarter and the preceding quarter. Based on the agronomics literature documenting strong effects of prolonged droughts on crop yields, we use this variable to capture realized rainfall shocks in producing municipalities (Nasir and Toth, 2022).

Our second measure of risk exposure is the coefficient of variation of daily rainfall over five-year moving windows. We use this variable to proxy for uncertainty about future rainfall realizations. Previous studies have used similar measures to identify the effects of income and consumption uncertainty in rural context (Colmer, 2021; Foster and Gehrke, 2017; Dercon and Christiaensen, 2011; Abay et al., 2022). The use of this proxy relies on the assumption that farmers form their expectations of future rainfall realizations based on past experiences. Supporting this assumption, Kala (2017) shows that farmers respond to observed rainfall variability by adjusting their predictions about future rainfall.

We motivate the use of the length of dry periods and the coefficient of variation of rainfall as measures of climate risk in our context by demonstrating their relationship with potato production in Colombian municipalities. We show that longer droughts are associated with a lower value of the production of potato sold by municipalities to the main urban areas. This suggests that the decrease in production induced by the lack of rainfall represents income losses for farmers. We also show that rainfall variability is not correlated with the value of production. We take this result as an evidence that our measure of rainfall variability captures a mean-preserving spread of farmers' income. This allows us to effectively disentangle the ex post effects of risk on credit, which we identify with the length of dry periods, and the ex ante effects, which we identify with rainfall variability.

We then evaluate the effects of droughts and rainfall variability on credit access. Consistent with the use of credit to smooth consumption, our results show that longer droughts increase the value of loan disbursements and the number borrowers in the municipality. In contrast, rainfall variability reduces credit access. Also, the interaction between rainfall rainfall variability and drought length shows that the increase in the value of loans and borrowers after longer droughts occurs only when the municipality has had a history of low rainfall variability. As uncertainty about the future rainfall increases, the credit response to droughts diminishes.

Additionally, our results suggest that after a drought, credit would be a consumption smoothing mechanism, but only for potato farmers whose loans are backed by a public-funded national guarantee scheme. Our results are suggestive of risk exposure as a relevant constraint to credit access and the effective role of the public guarantee scheme in mitigating this risk.

This paper contributes to two important areas of the economics literature. The first one relates to the study of household strategies for coping with the ex post effects of risk in developing countries. Previous studies have shown responses to income shocks that can have lasting effects on welfare. These responses include selling assets, reducing spending in children's education, increases in child marriage, migrating, changing crops, adjusting inputs, and reducing nutrition. (Jessoe et al., 2018; Jagnani et al., 2021; Aragón et al., 2021; Ibáñez et al., 2022; Rosenzweig and Wolpin, 1993; Jensen, 2000; Corno and Voena, 2023). Financial constraints that prevent households from using credit and savings to smooth consumption lead them to adopt these coping strategies (Paxson, 1992; Foster, 1995; Morduch, 1995; Jacoby and Skoufias, 1997). We contribute to this existing literature by showing that small farmers in Colombia use credit after negative income shocks. However, this response is weaker in areas with higher income uncertainty. This suggests that risk exposure worsens credit constraints, limiting households' ability to cope with income shocks.

The second area of literature explores the ex ante effects of risk exposure on agricultural households. Previous works show that households respond to uncertainty about future income by reducing investments in human capital (Foster and Gehrke, 2017; Kazianga, 2012; Fitzsimons, 2007; Colmer, 2021), decreasing the use of inputs (Dercon and Christiaensen, 2011), and opting for less risky, low-return technologies (Yesuf and Bluffstone, 2009). Moreover, increasing weather risk exposure also ex ante has effects on well-being by reducing household food expenditure, especially on those products with higher value, since they incur into precautionary savings to avoid falling into poverty in the future (Gansonré, 2024). We show that higher uncertainty about future rainfall reduces credit access.

The results we present in this paper are similar to previous works that have documented the relationship between climate risk and smallholders' credit access in developing countries. For example, In Ethiopia, the variability of precipitation, which results in greater uncertainty about agricultural returns, explains the low demand for agricultural credit (Abay et al., 2022). Likewise, in Mexico, an increase in the number of extreme heat days raises the delinquency rate on loans for small and medium-sized enterprises, especially in the agricultural sector, and restricts the supply of new credit, increasing the interest rate and collateral requirements (Aguilar-Gomez et al., 2024). Our main contribution corresponds to jointly analyze both ex ante and ex post effects of climate risk on credit access.

The remainder of this paper is organized as follows: Section 2 discusses how climate risk is a constraint to formal credit access in developing countries and characterizes potato production in Colombia. Section 3 defines the data used and presents some descriptive statistics. In Section 4 we describe the empirical strategy used to conduct the econometric estimations, whose results are presented in Section 5. Finally, Section 6 concludes.

2 Conceptual Framework

This section consists of three parts: first, we analyze how climate risk could be a credit constraint faced by agricultural producers in developing countries. Then, we briefly explain the institutional context of the credit system to agricultural producers in Colombia. Last, we present some key highlights regarding the production of potato in Colombia.

2.1 Risk as a Constraint to the Access to Formal Agricultural Credit in Developing Countries

Different types of risks in agriculture can affect crop yields and the profitability of the investments made by farmers (Komarek et al., 2020). Climate risk exposure could rise from climate variability and weather shocks, affecting the willingness to offer and demand credit (Abay et al., 2022; Aguilar-Gomez et al., 2024). Climate variability , often measured as rainfall variability, may increase income variability as well. Therefore, it can deter them from applying for a loan if their fear of losing collateral increases. When this happens, the farmer is said to be risk rationed (Boucher et al., 2008, 2009). This contraction in the demand for credit may be greater due to the low uptake of agricultural insurance that protects the investments made by farmers, in the face of losses such as droughts, floods, and frosts. On the other hand, lenders could offer less credit—or at higher interest rates—in certain geographic areas or to producers of given crops, if they are exposed to more climate variability. Hence, climate risk induced by rainfall variability could reduce credit supply and demand, which in turn, reduces credit access.

Besides, smallholders could increase their credit demand if a weather shock affects their incomes, since they might need to smooth their consumption and finance their next planting. Alternatively, farmers might decrease their demand for credit if they fear not being able to repay it. In addition, in the occurrence of a weather shock, farmers who already have a loan could default on their payments. This can damage their credit history and prevent them from getting another loan.

Lender's responses to a weather shock could be harder to predict: On the one hand, banks could offer less credit to farmers affected by the shock, as the risk of default may be higher. On the other hand, the lender could increase the credit supply to promote agricultural activity. This could be the case if the resources come from state-owned financial institutions. Therefore, the effects of climate risk, induced by weather shocks, on credit access could be ambiguous. In conclusion, more evidence is needed to understand the impact of climate risk on smallholders' access to credit, and our paper sheds some insights into this.

2.2 Agricultural Credit in Colombia: Institutional Framework

Colombia counts with a public-funded scheme of credit provision to agricultural producers. The Financial Fund for the Agricultural Sector (Finagro in Spanish) is the institution in charge of executing the policies aimed to increase credit supply to producers. Finagro serves as a second-floor bank, since it channels the public resources for agricultural credit throughout commercial banks. Finagro's ownership is shared between the Colombian government, represented by the Ministry of Agriculture, *Banco Agrario*—a State-owned commercial bank, and two other important private banks. As reported by Echavarría-Soto et al. (2018), on average more than 90 percent of Finagro-backed loans granted by commercial banks every year are placed to small producers, which represents abut 7.2 percent of the total value of agricultural credit. Banco Agrario grants the majority of credit disbursements to small producers.

Beyond regular credits, Finagro opens Special Credit Lines (LEC in Spanish) for a given amount of time in order to expand credit supply under extraordinary circumstances, like climate shocks, natural disasters, or unfavorable external conditions for exporting. These LEC provides loans with more favorable terms and lower interest rates, compared with the regular credits. The implementation of the LEC is discretionary by the Colombian government, and Finagro sets the interest rates before the opening of these credit lines. Additionally, in order to help producers with low collateral to increase their access to credit, Finagro offers being a co-signer throughout the Agricultural Guarantees Fund (FAG in Spanish). In case of default, the FAG commits with commercial banks to pay for the reminding of the loan.

2.3 Characterizing the Production of Potato in Colombia

Potato is the world's fourth most important food crop, after rice, maize, and wheat. For Colombia, is considered a key staple for most households. According to the Ministry of Agriculture, the production of potato is concentrated in two main areas: the plains of the departments of Boyaca and Cundinamarca, located in the center-east part of the country, and the department of Nariño, located in the southwest area. These two regions account for more than 90% of total production (Ministerio de Agricultura y Desarrollo Rural, 2021), mostly destined for domestic purposes: 92% for fresh consumption, while the remaining 8% is used by the food industry (Ministerio de Agricultura y Desarrollo Rural, 2022). Between 2010-2019, the average share of exports from total domestic production was 0.2%. Smallholders produce the majority of potato in Colombia: 63% of the farms are smaller than 3 hectares, and only 3% of the total are between 50 and 500 hectares.

The production of potato in Colombia is characterized by lacking proper irrigation and watering systems (Ministerio de Agricultura y Desarrollo Rural, 2022), making it highly dependent on rainfall. Farmer's common practice is to start planting during the rainy seasons. In Colombia, potatoes are grown all year round, but there are two important sowing seasons, beginning in the months of March and September, and the average growing cycle takes approximately 5 months (Barrios-Perez et al., 2023). There is not enough evidence of the effect of climate variability and weather shocks on potato yields in Colombia. However, some records suggest that droughts are the type of climate shocks that mostly affect the production of potato (Ministerio de Agricultura y Desarrollo Rural, 2021; Pino and Chen, 2016; Contexto Ganadero, 2015). Extended droughts and variability in water availability can affect planting schedules, crop yields, and producers' incomes. Thus, the impossibility of growers to anticipate the rain pattern perfectly represents a source of risk in potato production.

3 Data and Descriptive Statistics

Regarding production, we use the *Information System for Prices and Supply of the Agricultural Sector* (SIPSA in Spanish), administered by Colombia's National Statistics Department (DANE). SIPSA records prices of agricultural products at wholesale centrals across the country, and identifies the municipality from which each product is transported to the corresponding central. Based on this information, we calculate a measure of potato production in each producing municipality as the total volume (in kilograms) of potatoes transported to all wholesale centrals at any given quarter during the period 2013–2020.[1] We then compute production values for each municipality by multiplying production and weighted-average wholesale prices.

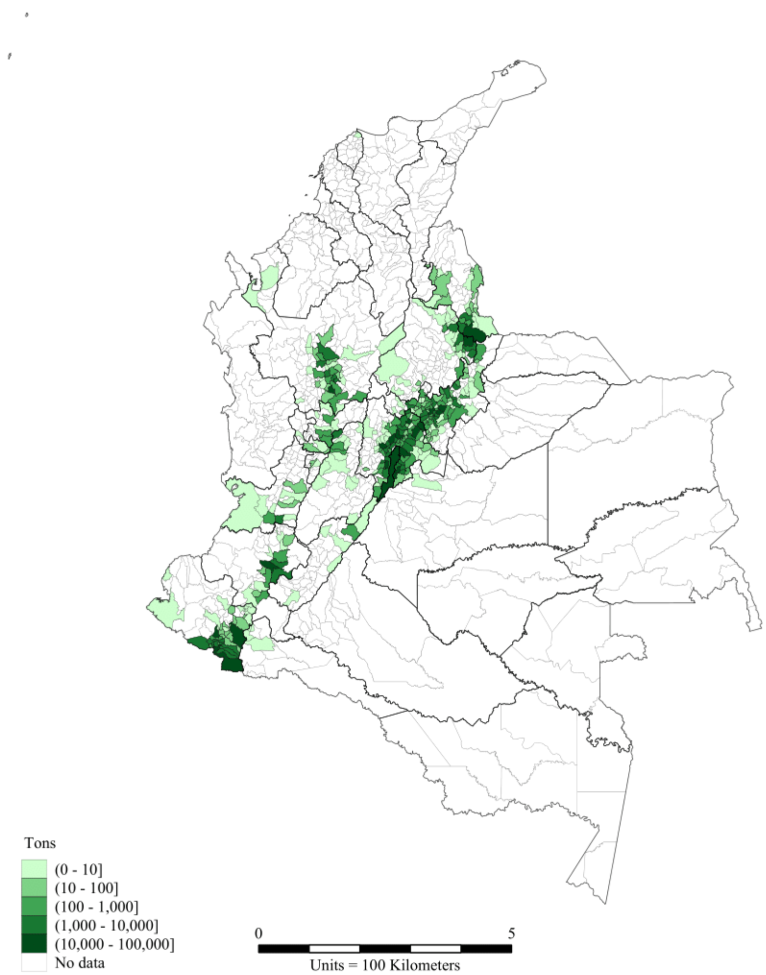
Figure 1 shows the geographical distribution of potato-producing municipalities in SIPSA. The map indicates that most potatoes supplied to Colombia's major wholesale centers originate from the Andean regions in the east and southwest, as explained in Section 2.3. Likewise, in Figure 2, we illustrate the evolution of potato production over the study period. The graph reveals an upward trend, with production increasing from over 160,000 tons in the first quarter of 2013 to more than 274,000 tons in the fourth quarter of 2020.

With respect to credit access, we use the official quarterly records on credit disbursements from commercial banks to agricultural producers, managed by Finagro.[2] The data includes producer-level characteristics (e.g., location, assets, main activity) as well as key features about loans (e.g., amount, maturity, interest rate, and public guarantees).

[1] We exclude municipalities with total potato production below the 1st percentile of the national distribution between the years of study.

[2] Available upon request at https://www.finagro.com.co/.

Figure 1: Geographical Location of Potato Producing Municipalities According to SIPSA

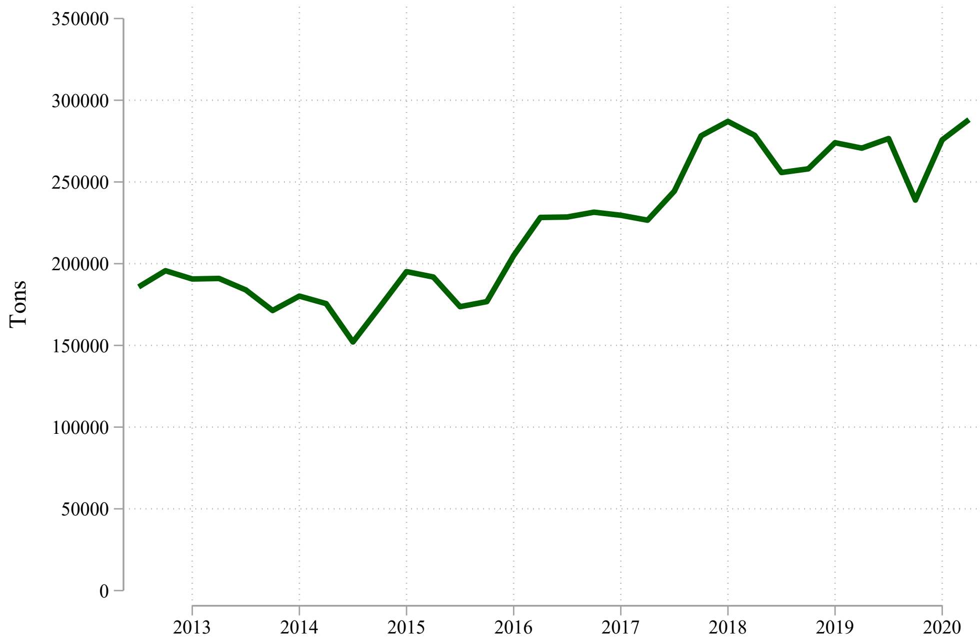


Note: Map indicates average annual production (in tons) for the period 2013-2020. Source: SIPSA

In this paper, we focus on loans to small potato growers, defined as those who received credit for any potato-related activity, such as production, investment, or working capital. Small producers are classified using asset thresholds set by the National Agricultural Credit Commission.[3] We exclude operations like debt restructuring, housing loans, and credit cards. With these data we construct our main outcome variables that include the value total loan disbursements, number of borrowers, average interest rate, and maturity by municipality and quarter.

[3]According to the National Agricultural Credit Commission, a grower is classified as small whether her total assets are less or equal than 284 monthly minimum wages.

Figure 2: Total Quarterly Potato Production, 2013-2020

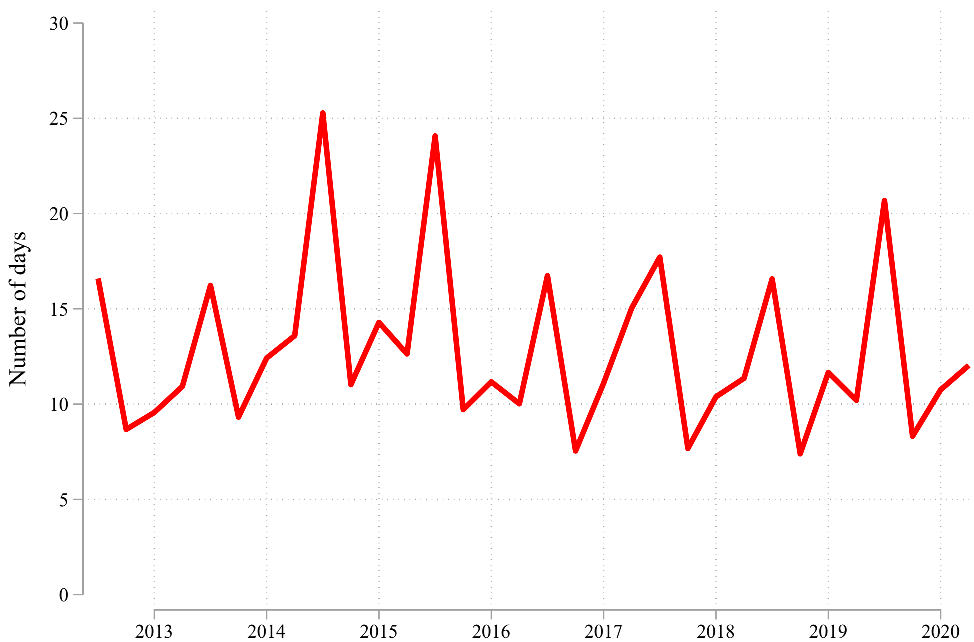


Source: SIPSA.

As explained in Section 2.3 precipitation is the main climate risk factor for potato producers due to the crop's substantial water requirements for optimal growth (Barrios-Perez et al., 2023). To measure this, we use high-resolution rainfall data from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), provided by the University of California, Santa Barbara. CHIRPS provides daily precipitation data from 1981 onward, covering the Colombian territory at a spatial resolution of $0.005° \times 0.005°$ (5 $\mathbf{km^2}$). For each municipality, we calculate daily rainfall as the average across all polygons within its boundaries.

Using this data, we construct two climate risk measures at the municipality-quarter level: *(i)* maximum consecutive dry days and *(ii)* daily rainfall variability. Consecutive dry days, which capture crop's exposure to droughts, serves as a measure of realized production shocks. Specifically, we calculate this metric as the maximum number of consecutive days with less than 1 mm of rainfall at a given municipality and quarter. To account for water availability throughout the crop cycle, our main specifications aggregate this measure across two consecutive quarters. Figure 3 shows that potato-producing municipalities experienced an average of 12.8 consecutive dry days per quarter between 2013 and 2019, with clear seasonal drought patterns across these regions.

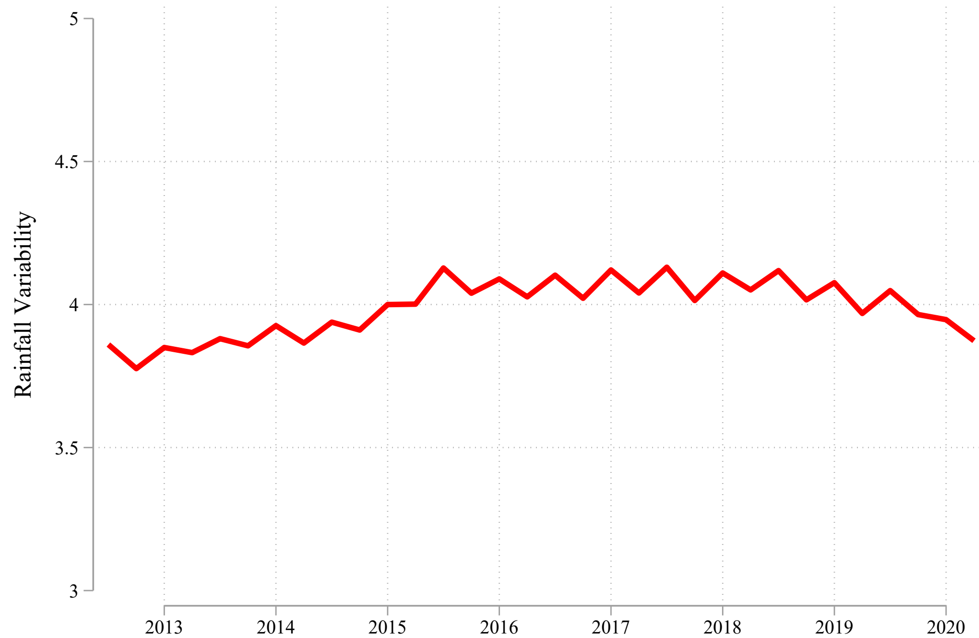
Figure 3: Length of Dry Periods at Potato Producing Municipalities, 2013-2020



Source: CHIRPS

Following Colmer (2021), we measure rainfall variability at each quarter as the coefficient of variation of daily rainfall, calculated over a five-year moving window for each municipality. As discussed further below, this measure captures farmers' uncertainty regarding future rainfall patterns and, consequently, future farm income. Figure 4 highlights significant variation in rainfall variability both across regions and over time within regions. Our empirical strategy exploits this variation to identify its effects on credit access.

Figure 4: Coefficient of Variation of Daily Rainfall, 2013-2023



Source: CHIRPS

4 Empirical Strategy

To study the effect of climate risk on credit access among our sample of farmers, we use aggregate data at the municipality and quarter levels to estimate the following equation:

$$y_{it} = \alpha_1 P_{it} + \alpha_2 CV_{it} + X'_{it}\beta + a_i + b_t + u_{it}, \tag{1}$$

where y_{it} represents credit outcomes, including the value of loan disbursements, the number of borrowers, the average interest rate, and the maturity of loans issued in municipality i during quarter t. The variables P_{it} and CV_{it} measure climate risk as described earlier: P_{it} is the average of the maximum consecutive dry days at t and $t-1$, averaged over two quarters to reflect rainfall conditions during the crop cycle. CV_{it} is the coefficient of variation of daily rainfall over 5-year moving windows.

The estimation includes municipality and quarter fixed effects (a_i and b_t, respectively) to account for differences in climate and production across municipalities, and macroeconomic shocks that affect all municipalities at a given time. Control variables X_{it} in our baseline specification include total rainfall in the municipality during quarter t and its corresponding lags, the squared values of each of those variables, and the average potato production over the past five years. These controls account for past and current climate conditions in the municipality and for potential trends in production that could be correlated with trends with our climate measures. Finally, u_{it} represents a stochastic error term.

By including municipality fixed effects (a_i), the identifying variation in Equation (1) comes from deviations of the variables of interest from their averages in each municipality over time. The coefficient α_1 captures the effect of longer-than-usual dry periods on our credit outcomes. Similarly, α_2 measures the effect on credit access of greater rainfall variability than usual in the municipality. Our empirical strategy uses the length of droughts a proxy for negative income shocks and the coefficient of variation of rainfall as a proxy for income uncertainty.

If longer dry periods represent a negative income shock for farmers, we should observe a decrease in the value of potato output in affected municipalities. To test this, we estimate Equation (1) using as dependent variable the value of output sold by each municipality to wholesale centrals in the country. Columns 1 and 2 of Table 1 present the baseline estimations, excluding and including the coefficient of variation of daily rainfall, respectively. Columns 3 and 4 include additional control variables. Specifically, column 3 controls for the maximum number of wet days during the crop cycle and the number of days with rainfall above the municipality's 90th percentile, accounting for potential crop losses from excessive rainfall. Column 4 adds measures of temperature shocks, including the average minimum and maximum temperatures and the number of days with maximum (minimum) temperatures above (below) the 90th (10th) percentile of the temperature distribution in the municipality between 1981 and 2020. Columns 1 to 5 include the baseline controls described above.

The results indicate that longer dry periods reduce the value of potato produce sold by municipalities to urban markets. The stability of the point estimates across specifications suggests that this effect is not driven by other shocks to output in the municipality. The reduction in production value implies that lower output due to the lack of precipitation is not fully offset by price adjustments. As a result, this decline in aggregate production value likely leads to income losses for farmers.

Table 1: The effects of rainfall variability and weather shocks on potato production

	(1) Production Value	(2) Production Value	(3) Production Value	(4) Production Value	(5) Production Value
Longest drought length (days)	-6.12**		-6.06**	-5.40**	-5.17**
	(2.58)		(2.50)	(2.44)	(2.42)
Rainfall Variability (20 quarters)		52.06	42.86	46.86	63.14
		(125.84)	(124.05)	(124.07)	(125.05)
Adj. R^2	0.866	0.866	0.866	0.867	0.867
Observations	11,284	11,284	11,284	11,284	11,284
Municipalities	364	364	364	364	364
Baseline controls	Yes	Yes	Yes	Yes	Yes
Excessive rainfall	No	No	No	Yes	Yes
Temperature shocks	No	No	No	No	Yes

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: We include additional control variables such as: precipitation (mm/quarter- year), precipitation squared, average precipitation in the last 20 quarters, and average potato production during the last 20 quarters. Sources: SIPSA, Finagro, Chirps and Copernicus. Own Estimations.

The coefficient α_2 in Equation (1) captures the effect of rainfall variability on credit access, net of realized rainfall shocks. Our interest lies in the effect of income variability on credit access, and we argue that rainfall variability can serve as a suitable proxy. In particular, we argue that the mechanism in which rainfall variability affects credit access is income uncertainty. Table 1 shows that conditional on the control variables, rainfall variability does not have a statistically significant effect on the contemporaneous value of production. Furthermore, the coefficient estimate of this variable remains largely unchanged after including alternative measures of weather shocks. Column 5 further confirms that even without any measures of climate shocks in the regression, rainfall variability has no statistically significant effect on production value. We interpret this as evidence that our measure of rainfall variability does not capture realized production shocks and can instead be interpreted as a mean-preserving spread of income.

5 Results

5.1 The Effects of Climate Risk on Credit Access

Table 2 presents the estimation results from Equation (1) for the different credit-related outcomes. The estimated coefficients suggest that a 1% increase in the duration of a drought generates an average increase of 0.89% (column 1) and 0.08% (column 2) in total credit amounts by municipality and the number of beneficiaries, respectively. This increase in credit disbursements after longer droughts, together with the decrease in production value already presented in Section 4, suggests that farmers might use credit as a mechanism to smooth consumption after negative income shocks. Additionally, columns 3, 4 and 5 of Table 2 show that the disbursements per borrower, the average interest rate and the maturity do not change with longer droughts.

On the other hand, Table 2 also shows the existence of a negative relationship between rainfall variability and credit access. Rainfall variability decreases the amount of credit in the municipality (column 1). This fall is driven by a reduction in the number of borrowers with disbursements (column 2), without changes in the average value of loans per borrower (column 3) or in the average interest rate (column 4). The null climate risk effect on the average interest rate could be explained by credit market regulations in Colombia. In particular, interest rate caps and Special Credit Lines (LEC), which offer loans with a fixed

Table 2: Effects of rainfall risk on credit access

	(1) Total Credit	(2) Borrowers	(3) Credit per Borrower	(4) Interest Rate	(5) Maturity
Longest drought length (days)	0.892***	0.078***	-0.016	-0.001	0.111
	(0.324)	(0.026)	(0.021)	(0.007)	(0.071)
Rainfall Variability (20 quarters)	-40.757*	-3.650**	0.543	0.239	-5.044**
	(23.285)	(1.823)	(0.647)	(0.262)	(2.257)
Adj. R^2	0.770	0.781	0.215	0.639	0.494
Observations	11,284	11,284	4,662	4,662	4,662
Municipalities	364	364	282	282	282
Baseline controls	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: We include additional control variables such as total precipitation (mm/quarter-year), precipitation squared, and average precipitation in the last 20 quarters. Sources: SIPSA, Finagro, Chirps and Copernicus. Own Estimations.

*** p<0.01, ** p<0.05, * p<0.1.

subsidy on the interest rate. Last, the results from column 5 reveals that when rainfall variability is higher, loans tend to have shorter terms.

So far, our results suggest an increase in loan disbursements after realized negative income shocks and decreases due to higher income uncertainty. These results are consistent with farmers using credit to smooth consumption after negative income shocks, while income uncertainty decreases credit access.

5.2 Potential Mechanisms

We now discuss the potential mechanisms underlying the observed effects of climate risk on credit access. The increase in the number of farmers obtaining loans after longer droughts, as displayed in Table 2, suggests that farmers demand credit for consumption smoothing after negative income shocks. However, it is also possible that the expansion of credit supply is the result of a policy response to support farmers facing income losses. As we explained in Section 2.3, Finagro offers Special Credit Lines (LEC) at subsidized interest rates, targeting specific groups based on policy goals, such as supporting farmers affected by weather shocks, natural disasters, export challenges, or forced displacement, among others.

To determine whether the observed increase in credit access after longer droughts is driven by these special credit lines, we estimate Equation (1), distinguishing between loans from LEC and regular agricultural credits (non-LEC). Table 3 shows that the increase in credit access after longer droughts is primarily driven by the regular loans. Our findings support the interpretation that farmers increase credit demand in response to income losses while ruling out the possibility that the observed effect stems entirely from an expansion in credit supply following the drought.[4]

Consistent with the results in Table 2, column 3 of Table 3 shows that there is no effect of climate risk on the average credit per borrower, regardless of having a LEC loan or not. Additionally, the small coefficients associated with the interest rate (Column 4) for LEC and non-LEC loans indicate that longer droughts do not affect them significantly. The drought length effect on maturity is similar for LEC and non-LEC credits.

The second mechanism of interest is the role of the Agricultural Guarantees Fund (FAG), which helps farmers without enough assets to back potential loans by serving as their co-signers. Table 4 further shows that the increase in credit access after longer droughts corresponds to loans backed by FAG. Banks may perceive producers affected by droughts as riskier and might only be willing to lend to those backed by the national scheme. The average interest rate response to climate risk is the same regardless of the type of collateral.

[4]Table A2 provides descriptive statistics for the variables used in the regressions and reports the drought elasticities of the dependent variables at their averages.

Table 3: LEC Vs. Non-LEC Effects of rainfall risk on credit access

	(1) Total Credit	(2) Borrowers	(3) Credit per Borrower	(4) Interest Rate	(5) Maturity
Panel A. LEC					
Longest drought length (days)	0.229	0.020	0.005	0.009**	0.178***
	(0.163)	(0.013)	(0.027)	(0.004)	(0.064)
Rainfall Variability (20 quarters)	-38.894***	-3.418***	0.605	-0.184	-3.115
	(11.779)	(0.917)	(0.730)	(0.129)	(2.262)
Adj. R^2	0.551	0.566	0.200	0.354	0.606
Observations	11,253	11,253	3,173	3,173	3,173
Municipalities	363	363	233	233	233
Baseline controls	Yes	Yes	Yes	Yes	Yes
Panel B. Non-LEC					
Longest drought length (days)	0.666***	0.058***	0.009	0.007***	0.165*
	(0.239)	(0.019)	(0.028)	(0.002)	(0.094)
Rainfall Variability (20 quarters)	-1.517	-0.261	0.170	0.263***	-8.209***
	(15.691)	(1.306)	(0.941)	(0.090)	(2.850)
Adj. R^2	0.505	0.510	0.155	0.201	0.503
Observations	11,253	11,253	3,435	3,435	3,435
Municipalities	363	363	258	258	258
Baseline controls	Yes	Yes	Yes	Yes	Yes

Note: We include additional control variables such as total precipitation (mm/quarter-year), precipitation squared, and average precipitation in the last 20 quarters. Sources: SIPSA, Finagro, Chirps and Copernicus. Own Estimations.
*** p<0.01, ** p<0.05, * p<0.1.

Moreover, the results from Table 5, which displays the estimates of Equation (1) after splitting our sample between those loans granted to farmers with assets above and/or below the median value, suggests that credit is used to smooth income regardless of the level of household assets and, therefore, the national public guarantee scheme could be mitigating the lack of collateral in producers, who cannot fully back their loans with their own assets. As displayed in the Table, the estimates shows a similar effect of droughts on credit access for producers with more and fewer assets.

We also test whether proximity to wholesale centrals plays a role in explaining the effect of weather risk on credit access. Extreme weather events can increase transaction costs for

Table 4: FAG Vs. Non-FAG Effects of rainfall risk on credit access

	(1) Total Credit	(2) Borrowers	(3) Credit per Borrower	(4) Interest Rate	(5) Maturity
Panel A. FAG					
Longest drought length (days)	0.914***	0.078***	-0.019	0.000	0.105
	(0.335)	(0.026)	(0.018)	(0.007)	(0.069)
Rainfall Variability (20 quarters)	-28.539	-2.985*	0.722	0.152	-5.507**
	(18.898)	(1.631)	(0.584)	(0.259)	(2.134)
Adj. R^2	0.776	0.780	0.275	0.646	0.518
Observations	11,253	11,253	4,593	4,593	4,593
Municipalities	363	363	280	280	280
Baseline controls	Yes	Yes	Yes	Yes	Yes
Panel B. Non-FAG					
Longest drought length (days)	-0.019	-0.000	-0.165	0.008	0.039
	(0.044)	(0.003)	(0.121)	(0.017)	(0.191)
Rainfall Variability (20 quarters)	-11.871**	-0.645**	5.214	0.599	1.306
	(5.488)	(0.264)	(4.523)	(0.737)	(5.983)
Adj. R^2	0.412	0.454	0.147	0.467	0.320
Observations	11,253	11,253	1,203	1,203	1,203
Municipalities	363	363	126	126	126
Baseline controls	Yes	Yes	Yes	Yes	Yes

Note: We include additional control variables such as total precipitation (mm/quarter-year), precipitation squared, and average precipitation in the last 20 quarters. Sources: SIPSA, Finagro, Chirps and Copernicus. Own Estimations.
*** p<0.01, ** p<0.05, * p<0.1.

producers, including credit, if producing municipalities are isolated from the main markets. According to Ayala-García and Pérez-Ruidiaz (2024), transportation costs go up after the occurrence of weather-induced events like landslides or floods. These increments, in addition to lower expected returns from agriculture in remote areas, could limit the use of credit as a mechanism for smoothing consumption. For each producing municipality, we calculate the distance to its closest wholesale central, and from that distribution we split our sample across the median. Table 6 displays the results for these sub-samples, showing that the occurrence of droughts is positively related with credit access for those municipalities closer to main markets.

Table 5: Effects of rainfall risk on credit access by size of borrower's assets

	(1) Total Credit	(2) Borrowers	(3) Credit per Borrower	(4) Interest Rate	(5) Maturity
Panel A. Assets above median					
Longest drought length (days)	0.593**	0.044***	-0.014	-0.003	0.055
	(0.233)	(0.016)	(0.024)	(0.008)	(0.081)
Rainfall Variability (20 quarters)	-40.324**	-3.545***	0.581	0.281	-3.119
	(20.142)	(1.369)	(0.741)	(0.245)	(2.232)
Adj. R^2	0.685	0.706	0.229	0.628	0.485
Observations	11,253	11,253	4,088	4,088	4,088
Municipalities	363	363	255	255	255
Baseline controls	Yes	Yes	Yes	Yes	Yes
Panel B. Aseets below median					
Longest drought length (days)	0.302***	0.034***	-0.001	-0.005	0.081
	(0.115)	(0.013)	(0.014)	(0.008)	(0.067)
Rainfall Variability (20 quarters)	-0.087	-0.077	1.082*	0.444	-5.503**
	(5.181)	(0.647)	(0.590)	(0.322)	(2.527)
Adj. R^2	0.820	0.795	0.228	0.640	0.519
Observations	11,253	11,253	3,240	3,240	3,240
Municipalities	363	363	229	229	229
Baseline controls	Yes	Yes	Yes	Yes	Yes

Note: We include additional control variables such as total precipitation (mm/quarter-year), precipitation squared, and average precipitation in the last 20 quarters. Sources: SIPSA, Finagro, Chirps and Copernicus. Own Estimations.
*** p<0.01, ** p<0.05, * p<0.1.

Last, we analyze the mechanisms that could be explaining the negative relationship between loan disbursements and number of beneficiaries with rainfall variability, as displayed in Table 2. We find that it principally comes from the special credit lines (LEC), those loans not backed by FAG, loans granted to producers with a higher level of assets, and in municipalities that are further away from the main cities (see Columns 1 and 2 in Tables 3 to 6).

The fact that climate uncertainty has a greater effect on producers with total assets above the median (Table 5) is consistent with the model proposed by Boucher et al. (2008) on credit demand rationing by risk. According to this model, producers with higher levels of assets would reduce their demand for credit, since they may perceive a higher risk of

Table 6: Effects of rainfall risk on credit access by distance to nearest market

	(1) Total Credit	(2) Borrowers	(3) Credit per Borrower	(4) Interest Rate	(5) Maturity
Panel A. Closest to the market					
Longest drought length (days)	0.953***	0.083***	-0.046	-0.006	-0.012
	(0.357)	(0.029)	(0.031)	(0.008)	(0.077)
Rainfall Variability (20 quarters)	-39.897	-3.657	1.677**	0.350	-3.727
	(28.477)	(2.251)	(0.731)	(0.357)	(2.383)
Adj. R^2	0.794	0.802	0.242	0.648	0.500
Observations	9,406	9,406	2,854	2,854	2,854
Municipalities	344	344	160	160	160
Baseline controls	Yes	Yes	Yes	Yes	Yes
Panel B. Far away from the market					
Longest drought length (days)	0.143	0.012	0.058*	-0.002	0.272**
	(0.165)	(0.013)	(0.034)	(0.014)	(0.137)
Rainfall Variability (20 quarters)	-28.560***	-2.421***	-1.183	0.036	-6.226
	(7.378)	(0.567)	(1.343)	(0.340)	(4.594)
Adj. R^2	0.633	0.643	0.165	0.632	0.501
Observations	8,358	8,358	1,808	1,808	1,808
Municipalities	315	315	122	122	122
Baseline controls	Yes	Yes	Yes	Yes	Yes

Note: We include additional control variables such as total precipitation (mm/quarter-year), precipitation squared, and average precipitation in the last 20 quarters. Sources: SIPSA, Finagro, Chirps and Copernicus. Own Estimations.
*** p<0.01, ** p<0.05, * p<0.1.

losing their assets as rainfall variability increases. Also, in concordance with Boucher et al. (2008), the estimated positive effect of rainfall variability on interest rates for non-LEC loans (Column 4 of Table 3) would be the result of a shift in the pool of applicants into those with higher risk of default, making banks to increase the price of loans.

The aforementioned mechanisms are consistent with a contraction in credit demand in response to greater climate uncertainty. However, it is not possible to completely rule out that they also stem from a contraction in supply in response to an increase in the risk perceived by financial intermediaries. However, results show that the maturity penalty in places with higher rainfall variability comes from different types of loans: regular loans (non-LEC), loans backed by FAG, and loans granted to producers with a lower level of assets (Column 5 in Tables 3 to 6).

5.3 The Interaction Between Realized Shocks and Uncertainty

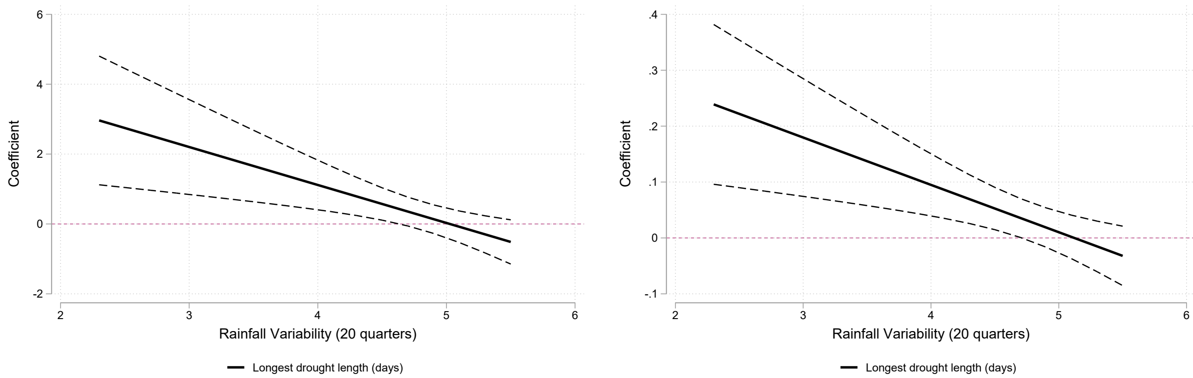
We explore whether rainfall variability limits the credit response to longer droughts. To do so, we estimate equation 1, including the interaction between the coefficient of variation in rainfall and the length of dry periods ($P_{it} \times CV_{it}$). The coefficient of this interaction provides information on the effect of an increase in the number of dry days for different rainfall variability levels.

Figure 5 summarizes these results. The figure shows that the increase in the value of disbursements (Panel A) and borrowers (Panel B) after longer droughts occurs when the municipality has had a history of low rainfall variability. As uncertainty about the future rainfall pattern increases, due to an increase in its past variability, the credit response to dry days is reduced to zero. The results suggest that potato producers use credit to smooth consumption following negative productivity shocks associated with droughts. However, climate uncertainty reduces credit access, limiting its use to smooth out those weather shocks.

6 Final Remarks

This paper assesses both the ex post and ex ante effects of climate risk on credit access for small producers of potato in Colombia. First, we explore the ex post effects that come after droughts, a negative climate shock. Second, we investigate the ex ante effects through the uncertainty surrounding future climate realizations, using rainfall variability as a proxy of that uncertainty. Finally, we analyze how these two effects interact to influence farmers' use

Figure 5: Total marginal effects of weather shocks on credit disbursements and the number of borrowers



(a) Loans (b) Borrowers

Note: Dashed lines correspond to the confidence internal at 95 percent of significance. Bold lines refer to the total marginal effect evaluated at each point of the distribution of rainfall variability. Sources: SIPSA, Finagro, Chirps and Copernicus. Own Estimations.

of credit as a coping mechanism for climate risk.

Our results suggest that climate risk plays a relevant role in credit access to potato producers: Longer droughts increase total loans disbursed and the number of borrowers. On the other hand, the results suggest that rainfall variability is associated with less credit access. This could reflect a lower interest of households to borrow under scenarios of greater uncertainty or a lower willingness of financial intermediaries to offer credit in these places. Additionally, we found that after a drought, credit might act as an ex post income smoothing mechanism in municipalities with low rainfall variability. These results are consistent regardless the total value of household assets, or the presence of a public-funded guarantee scheme that helps to mitigate the lack of collateral in producers who cannot back debts with their own assets. With respect to the interest rate, results show that climate risk does not impact it significantly, which could be explained by the interest rate caps and subsidized rates for smallholders in the Colombian context.

It is possible to draw some relevant policy implications from our analysis. On one hand, identifying the barriers that impede access to credit in municipalities farthest from the main markets is relevant to the design of policies that seek to provide consumption-smoothing mechanisms in the most vulnerable households. On the other hand, if climate change is expected to increase variability in rainfall patterns and generate more frequent, intense, and less predictable droughts, credit effectiveness as an income-smoothing mechanism or a way to overcome financial constraints that prevent technology adoption, could be limited. Recognizing the climate risk and considering actions to mitigate it should be part of the adaptation policies with respect to climate change.

References

Abay, K. A., Koru, B., Chamberlin, J., and Berhane, G. (2022). Does rainfall variability explain low uptake of agricultural credit? evidence from ethiopia. *European Review of Agricultural Economics*, 49(1):182–207.

Aguilar-Gomez, S., Gutierrez, E., Heres, D., Jaume, D., and Tobal, M. (2024). Thermal stress and financial distress: Extreme temperatures and firms' loan defaults in mexico. *Journal of Development Economics*, 168:103246.

Aragón, F. M., Oteiza, F., and Rud, J. P. (2021). Climate change and agriculture: subsistence farmers' response to extreme heat. *American Economic Journal: Economic Policy*, 13(1):1–35.

Ayala-García, J. and Pérez-Ruidiaz, D. (2024). Impacto de los desastres naturales en la vía al llano sobre el movimiento de carga. *Documentos de Trabajo Sobre Economía Regional y Urbana*, (329).

Barrios-Perez, C., Saavedra, C., and Gonzalez, C. (2023). Caracterización del impacto de eventos climáticos extremos en las regiones productoras de papa en colombia. Technical report, Alianza Bioversity & CIAT. Área de Modelación Agroclimática.

Boucher, S. R., Carter, M. R., and Guirkinger, C. (2008). Risk rationing and wealth effects in credit markets: Theory and implications for agricultural development. *American Journal of Agricultural Economics*, 90(2):409–423.

Boucher, S. R., Guirkinger, C., and Trivelli, C. (2009). Direct elicitation of credit constraints: Conceptual and practical issues with an application to peruvian agriculture. *Economic development and cultural change*, 57(4):609–640.

Colmer, J. (2021). Rainfall variability, child labor, and human capital accumulation in rural ethiopia. *American Journal of Agricultural Economics*, 103(3):858–877.

Contexto Ganadero (2015). Producción de papa disminuye un 20 % por heladas y sequía.

Corno, L. and Voena, A. (2023). Child marriage as informal insurance: Empirical evidence and policy simulations. *Journal of Development Economics*, 162:103047.

de Roux, N. (2021). Exogenous shocks, credit reports and access to credit: Evidence from colombian coffee producers. *Documento CEDE*, (57).

Dercon, S. and Christiaensen, L. (2011). Consumption risk, technology adoption and poverty traps: Evidence from ethiopia. *Journal of development economics*, 96(2):159–173.

Echavarría-Soto, J. J., Villamizar-Villegas, M., and Restrepo-Tamayo, S., editors (2018). *Superando barreras: el impacto del crédito en el sector agrario en Colombia*. Number 2018-07 in Books. Banco de la Republica de Colombia.

Fafchamps, M. and Lund, S. (2003). Risk-sharing networks in rural philippines. *Journal of development Economics*, 71(2):261–287.

Fitzsimons, E. (2007). The effects of risk on education in indonesia. *Economic Development and Cultural Change*, 56(1):1–25.

Foster, A. D. (1995). Prices, credit markets and child growth in low-income rural areas. *The economic journal*, 105(430):551–570.

Foster, A. D. and Gehrke, E. (2017). Start what you finish! ex ante risk and schooling investments in the presence of dynamic complementarities. Technical report, National Bureau of Economic Research.

Gansonré, S. (2024). Rainfall variability and welfare of agricultural households: Evidence from rural niger. *Agricultural Economics*, 55(4):572–587.

Ibáñez, A. M., Quigua, J., Romero, J., and Velásquez, A. (2022). Responses to temperature shocks: Labor markets and migration decisions in el salvador. Technical report, IDB Working Paper Series.

Jacoby, H. G. and Skoufias, E. (1997). Risk, financial markets, and human capital in a developing country. *The Review of Economic Studies*, 64(3):311–335.

Jagnani, M., Barrett, C. B., Liu, Y., and You, L. (2021). Within-season producer response to warmer temperatures: Defensive investments by kenyan farmers. *The Economic Journal*, 131(633):392–419.

Jensen, R. (2000). Agricultural volatility and investments in children. *American Economic Review*, 90(2):399–404.

Jessoe, K., Manning, D. T., and Taylor, J. E. (2018). Climate change and labour allocation in rural mexico: Evidence from annual fluctuations in weather. *The Economic Journal*, 128(608):230–261.

Kala, N. (2017). Learning, adaptation, and climate uncertainty: Evidence from indian agriculture. *MIT Center for energy and environmental policy research working paper*, 23.

Kazianga, H. (2012). Income risk and household schooling decisions in burkina faso. *World Development*, 40(8):1647–1662.

Komarek, A. M., De Pinto, A., and Smith, V. H. (2020). A review of types of risks in agriculture: What we know and what we need to know. *Agricultural Systems*, 178:102738.

Ministerio de Agricultura y Desarrollo Rural (2021). Cadena de la papa. Technical report, Dirección de Cadenas Agrícolas y Forestales.

Ministerio de Agricultura y Desarrollo Rural (2022). Análisis situacional cadena de papa en colombia. Technical report, Equipo Análisis Situacional y Prospectiva UPRA.

Morduch, J. (1995). Income smoothing and consumption smoothing. *Journal of economic perspectives*, 9(3):103–114.

Nasir, M. W. and Toth, Z. (2022). Effect of drought stress on potato production: A review. *Agronomy*, 12(3):635.

Paxson, C. H. (1992). Using weather variability to estimate the response of savings to transitory income in thailand. *The American Economic Review*, pages 15–33.

Pino, M. and Chen, T. (2016). Efectos de las heladas en el cultivo de papa, y desafíos del mejoramiento genético. In Pino, M.-T., editor, *Estrés Hídrico y Térmico En Papas, Avances y Protocolos*.

Rosenzweig, M. R. and Wolpin, K. I. (1993). Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investments in bullocks in india. *Journal of political economy*, 101(2):223–244.

Udry, C. (1990). Credit markets in northern nigeria: Credit as insurance in a rural economy. *The World Bank Economic Review*, 4(3):251–269.

Yesuf, M. and Bluffstone, R. A. (2009). Poverty, risk aversion, and path dependence in low-income countries: Experimental evidence from ethiopia. *American Journal of Agricultural Economics*, 91(4):1022–1037.

Appendix

Tables

Table A1: Descriptive Statistics of Variables from Tables 1 and 2

Variable	Units	Obs	Mean	Std. Dev.	Min	Max	Elasticity Longest drought length (days)
Panel A:							
Production value	Million COP	11284	556.01	2345.12	0	49672.6	-0.139
Total credit	Million COP	11284	57.64	180.2	0	3728.91	0.198
Borrowers	Individuals	11284	5.05	15.01	0	273	0.195
Precipitation	mm	11284	379.37	205.12	0	1860.963	
Longest drought length (days)	Days	11284	12.78	5.75	1	124.5	
Panel B:							
Credit per borrower	Million COP	4662	11.15	5.33	0.96	100.82	-0.018
Interest rate	%	4662	3.98	2.49	-1.1	7	-0.002
Maturity	Months	4662	22.27	19.54	6	132	0.065
Precipitation	mm	4662	326.66	164.3	72.14	1275.22	
Longest drought length (days)	Days	4662	13.16	4.91	2	33	

Table A2: Descriptive Statistics of Variables from Tables 3 to 6

Variable	Units	Obs	Mean	Std. Dev.	Min	Max	Elasticity Longest drought length (days)
Panel A: LEC							
Total credit LEC	Million COP	11253	27.68	107.94	0	2261.87	0.105
Borrowers LEC	Individuals	11253	2.41	8.87	0	155	0.101
Total credit non-LEC	Million COP	11253	30.11	116.74	0	2765.61	0.283
Borrowers non-LEC	Individuals	11253	2.66	9.92	0	224	0.279
Panel B: FAG							
Total credit FAG	Million COP	11253	53.37	167.06	0	3555.75	0.218
Borrowers FAG	Individuals	11253	4.83	14.39	0	268	0.204
Total credit non-FAG	Million COP	11253	4.42	20.68	0	525.55	-0.055
Borrowers non-FAG	Individuals	11253	0.23	1.02	0	27	-0.056
Panel C: Assets							
Total credit Assests above median	Million COP	11253	18.12	70.79	0	1459.83	0.212
Borrowers Assests above median	Individuals	11253	2.06	7.69	0	158	0.211
Total credit Assests below median	Million COP	11253	39.67	122.06	0	2282.67	0.191
Borrowers Assests below median	Individuals	11253	3	8.51	0	126	0.183
Panel D: Distance							
Total credit Closest to the market	Million COP	9406	51.19	182.41	0	3728.91	0.238
Borrowers Closest to the market	Individuals	9406	4.52	15.34	0	273	0.235
Total credit Far away from the market	Million COP	8358	20.21	86.73	0	2065.91	0.090
Borrowers Far away from the market	Individuals	8358	1.75	7.04	0	161	0.088