Impact of Physical Climatic Shocks on the Conditions for Granting Mortgage Loans in Mexico

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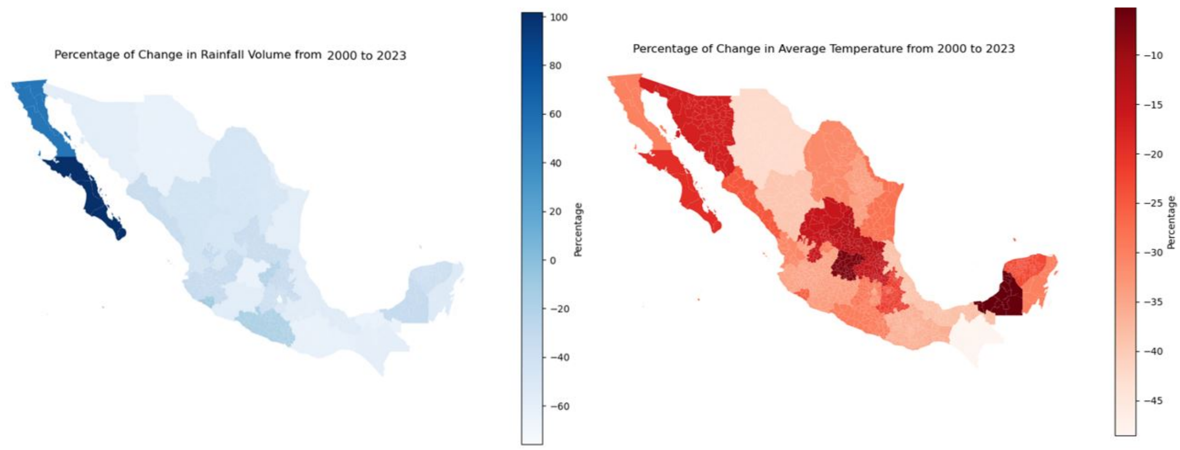
1 Introduction

Climate change is defined as the variation in the state of the climate that can be identified by changes in the mean or variance of its properties persistently over an extended period according to the Intergovernmental Panel on Climate Change (IPCC) (2018). This phenomenon can occur due to a variety of factors, but persistent anthropogenic changes in the composition of the atmosphere or land use is one of the main ones.

As a result of climate change, substantial alterations in temperature and precipitation patterns have been observed over the past decades. Figure 1 illustrates the percentage change in annual precipitation (measured in mm^3) between 2000 and 2023. Furthermore, it depicts the percentage change in the annual average temperature across states for the same period.

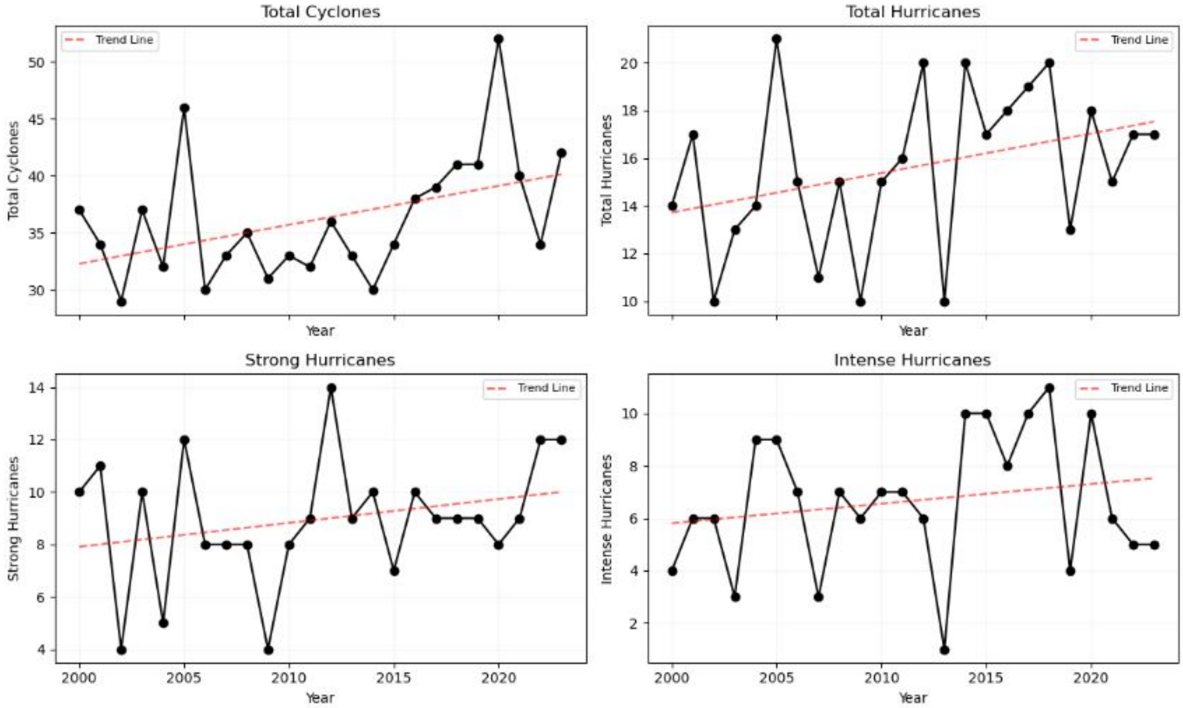
Figure 1: Changes in Weather Conditions from 2000 to 2023.



Source: Own elaboration based on data from CONAGUA.

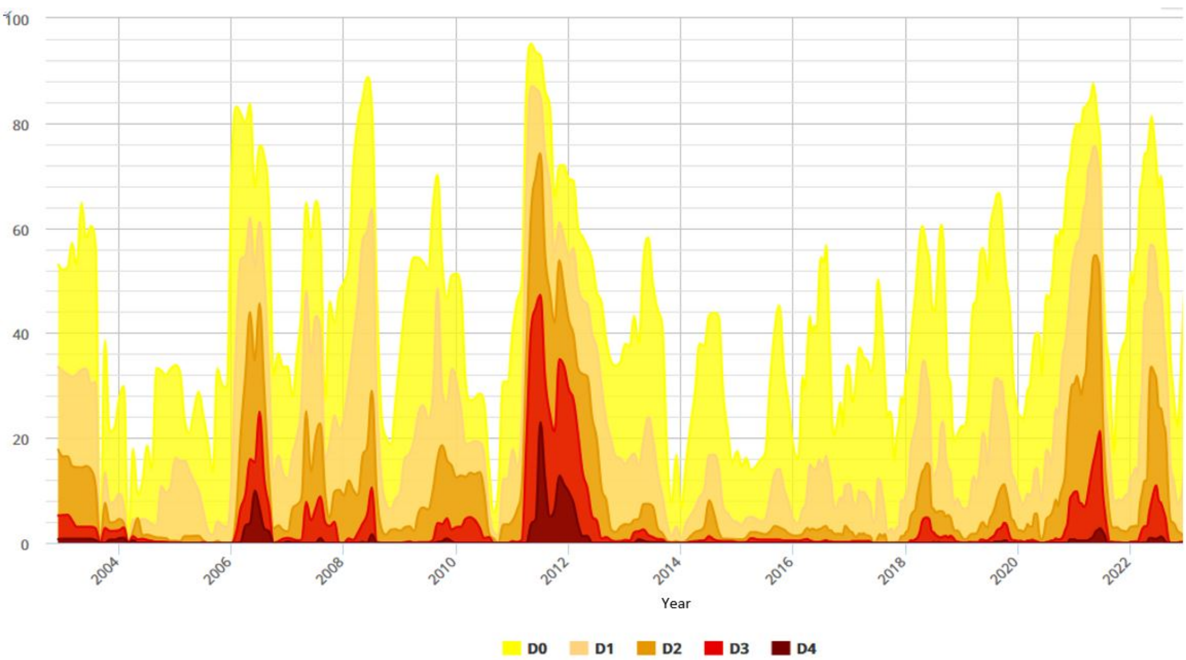
These changes have caused an increase in the intensity of weather phenomena such as tropical cyclones, thunderstorms, hurricanes, precipitation volumes, droughts, frosts, among others.

Figure 2: Annual Number of Hydrometeorological Phenomena (Cyclones) from 2000 to 2023.



Source: Own elaboration based on data from CONAGUA.

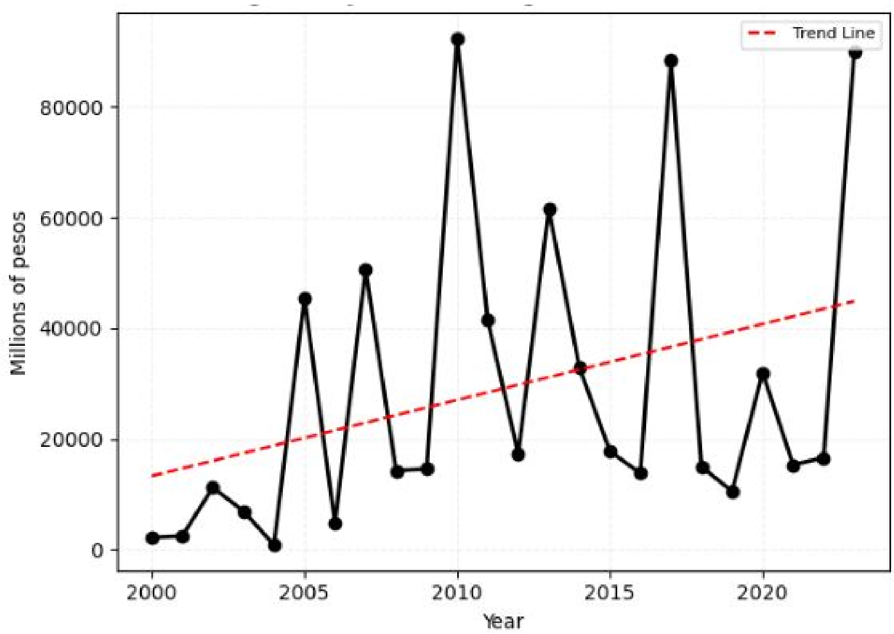
Figure 3: Percentage of the country's land area affected by drought from 2003 to 2023.



Source: Obtained from CONAGUA.

In conjunction with the intensity, the economic-financial effects of these phenomena have been increasing.

Figure 4: Amount of Damages of Hydrometeorological Phenomena from 2000 to 2023.



Source: Own elaboration based on data from CENAPRED.

From here, we can define **climate risk** as the financial risk posed by the impacts of climate change and how society and government adapt to these impacts. To be more precise, we will understand **physical risks** as those related to direct damage to infrastructure due to climate causes and we will have two categories of these: *acute*, which refer to sudden and unexpected shocks, such as a hurricane; *chronic*, which refer to changes that occur over a longer period of time. On the other hand, we will use **transition risks** as a concept that refers to risks related to changes in legislation, business models, technology, as well as reputational and legal risks derived from climate change

Given the above and the growing concern about climate change, regulators, supervisors and market participants have begun to study the implications of climate change risks on the financial sector and financial stability (Federal Reserve, 2021). In Mexico, it is particularly important to analyze the effects of physical risk because, given its geographic position, the country is likely to experience increasingly severe weather events, (World Bank Group, 2021) .

In this study we analyzed the implications of the impact of a physical risk on credit granting conditions in the Mexican mortgage market. For this purpose, we considered three hydrometeorological phenomena of considerable impact: First, Hurricane “Alex”, which occurred in June 2010; second, a long-time drought in the state of San Luis Potosí between January and May 2019; and finally, Hurricane “Otis”, which occurred in October 2023.

The importance of analyzing credit granting conditions lies in the fact that they largely determine the accessibility of financing for households, which in turn affects both the demand for housing and the financial stability of banking institutions. In the context of physical climate risks, it is essential to understand how financial institutions respond to such shocks, since phenomena such as droughts, hurricanes or tropical storms can heighten the perception of risk, leading to adjustments in credit terms. These adjustments, which may include increases in interest rates, changes in credit term, or modifications in origination fees, reflect the mitigation measures adopted by banks to compensate for the uncertainty generated by extreme weather events. Evidence suggests that, as physical shocks increase in frequency and intensity, banks need to take a more proactive approach to integrate climate risk into their lending models, ensuring both the financial viability of borrowers and the resilience of the financial system.

2 Literature Review

The impact of climate change on financial systems, particularly on credit markets, has attracted increasing attention from both academics and regulators in recent years. In this section we present a review of the literature on climate shocks, their influence on financial markets, and their potential effects on mortgage lending, aiming to highlight key findings rather than provide an exhaustive analysis.

Climate change and extreme weather events are altering financial market dynamics. Physical and transition risks are widely documented as factors modifying risk perception and investment decisions. Bolton et al. (2020) highlight how the increased frequency of climate shocks generates instability in financial markets, forcing banks to reevaluate their credit risk models.

Studies such as Dell et al. (2012) have shown that extreme weather events can negatively influence economic growth and financial stability, especially in developing countries . In this context, the ability of financial systems to adapt to these risks is crucial to mitigate adverse impacts

The mortgage sector is particularly vulnerable to climatic shocks due to the direct relationship between housing and environmental phenomena. Papers such as Keenan et al. (2018), highlight how hurricanes and floods affect property values and thus the quality of mortgage collateral . Likewise, Bunten and Kahn (2014) document how natural disasters can increase the risk of mortgage default and modify credit conditions .

On the other hand, empirical studies have analyzed the specific effects of hurricanes and droughts in emerging markets. For example, Strobl (2011) finds that hurricanes significantly reduce economic growth in affected countries, and their effects are intensified in vulnerable coastal regions, which can exacerbate credit delinquency problems and affect the real estate sector . Also, Fernández et al. (2023) find that prolonged droughts in Chile reduce local economic activity and increase financial problems, including credit delinquency in rural communities. This study highlights the vulnerability of emerging economies to the impacts of extreme weather events and the need for adaptation strategies in financial markets.

The regulatory framework also plays an important role in how banks respond to climate risks. The Network for Greening the Financial System (NGFS) (2021) emphasizes the need to incorporate climate scenarios into financial risk analysis to ensure system stability. In Mexico, the Comisión Nacional Bancaria y de Valores (CNBV) (2024) has begun to include climate risk guidelines in bank supervisory policies

Despite advances in the literature, there are important gaps in the analysis of climate risks impacts in emerging economies. While global studies focus on droughts, floods and transition risks, there is little evidence on the impacts of hurricanes on mortgage markets.

In Mexico, research on climate risks has focused on agricultural and urban sectors, but specific analysis of the mortgage sector is still limited. This study contributes to fill this gap by analyzing the case of various states in Mexico, using the synthetic control technique to assess the effects of a significant hurricane or drought on mortgage lending conditions.

In summary, the literature highlights the growing importance of integrating climate change into financial analysis. However, current approaches focus on global climate risks and require greater specificity in local contexts, such as the Mexican mortgage market, which underlines the relevance and originality of the present work.

3 Data

To conduct the research, we used information on mortgage lending conditions collected by the CNBV through form R04H-491 (hereafter R04H). The data reported are granular, at the level of each transaction for all banks operating in Mexico. For each loan, we used the following characteristics: reporting period, bank code, Federal Taxpayers Registry (RFC, by its initials in Spanish) of the borrower, gender, age, marital status, municipality of residence, state of residence, country of residence, monthly income, type of income verification, interest rate, unique credit identifier, credit destination, credit amount, credit maturity date, periodicity of capital contribution, loan origination fees,presence of a co-borrower, home value, date of granting, debt to income ratio (DTI), and loan to value ratio (LTV).

To avoid taking information with reporting errors, we performed a data treatment consisting of retaining information that falls between the percentiles that took as lower limit 0 or 0.5 and upper limit 99 or 99.5 in the following variables: monthly income, loan amount, LTV and DTI.

Additionally, we considered information from the Emergency Declarations database published in the Official Gazette of the Federation (DOF, by its initials in Spanish) by the National Center for Disaster Prevention (CENAPRED, by its initials in Spanish). Using this data, we identified the type of phenomenon to be analyzed in the study. The database includes information on the start and end dates, publication date in the DOF, classification of the phenomenon (e.g., hydrometeorological, geological, chemical, or socio-organizational), type of phenomenon (subcategories within the classification, such as hydrometeorological - droughts), state, municipality, and type of declaration. The type of declaration is further divided into three levels: climatological contingency, disaster, and emergency.

An emergency declaration is:

> “The act by which the Secretariat recognizes that one or several municipalities or delegations of one or more federal entities are facing the imminence, high probability or presence of an abnormal situation generated by a natural disturbing agent and therefore it is required to provide immediate assistance to the population whose safety and integrity are at risk” (Centro Nacional de Prevención de Desastres (CENAPRED), 2024).

While a natural disaster declaration is:

> ”[. . .] the act by which the Ministry of the Interior recognizes the presence of a severe natural disturbing agent in certain municipalities or delegations of one

or more federal entities, whose damages exceed the local financial and operational capacity for its attention are at risk" (Centro Nacional de Prevención de Desastres (CENAPRED), 2024).

Weather contingencies are those weather events that represent a moderate risk to the population or damage to infrastructure.

Finally, we also considered information on the economic impact resulting from selected events. For this purpose, we used the following variables in this database: date of onset and end of the event, classification of the event, type of event, state where the event occurred and total damages in millions of mexican pesos.

To analyze the previously described information, we first selected the phenomenon to be analyzed. For this, we took the information from the emergency declarations of hydrometeorological phenomena categorized as emergencies or disaster declarations. The types of phenomena analyzed were hurricanes and droughts. Additionally, it was necessary to have an economic quantification of the damage caused by the climatological events to ensure their significance in the affected areas.

With these characteristics, we selected:

- Hurricane Alex: A Category II hurricane on the Saffir-Simpson scale. This phenomenon originated in the Atlantic Ocean and made landfall in four states of the Mexican Republic. It reached maximum winds of 195 km/h and caused an estimated economic impact of approximately $25 billion pesos. This event occurred in June 2010 (Servicio Meteorológico Nacional (SMN), 2010), (Centro Nacional de Prevención de Desastres (CENAPRED), 2023).

- San Luis Potosí Drought: A Category D2 (severe drought) that lasted six months. The estimated economic impact was approximately $1.5 billion pesos. This event took place between January and June 2019 (Servicio Meteorológico Nacional (SMN), 2024).

- Hurricane Otis: A Category V hurricane on the Saffir-Simpson scale. This phenomenon originated in the Pacific Ocean and made landfall in one state of the Mexican Republic. It reached maximum winds of 330 km/h and caused an estimated economic impact of approximately $88 billion pesos. This event occurred in October 2023 (Servicio Meteorológico Nacional (SMN), 2023), (Centro Nacional de Prevención de Desastres (CENAPRED), 2023).

4 Descriptive Analysis

4.1 Hurricane Alex

Initially, it is important to visually identify the regions designated as the treatment group, which, in fact, exhibit a trajectory distinct from the actual path followed by the hurricane.

Figure 5: Treated states.

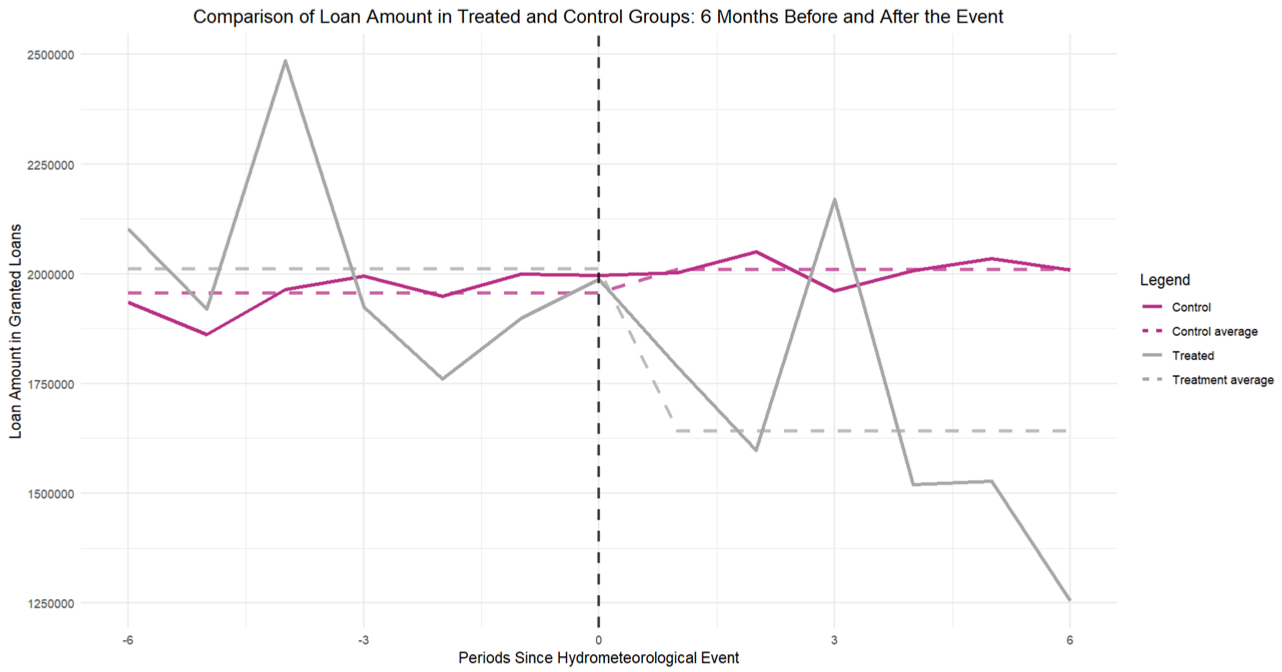
Source: Own elaboration based on data from CENAPRED.

The full trajectory of the hurricane affected the states of Quintana Roo, Tamaulipas, Coahuila, and Nuevo León. However, despite the significant damage in Quintana Roo, it did not lead to an emergency declaration by CENAPRED.

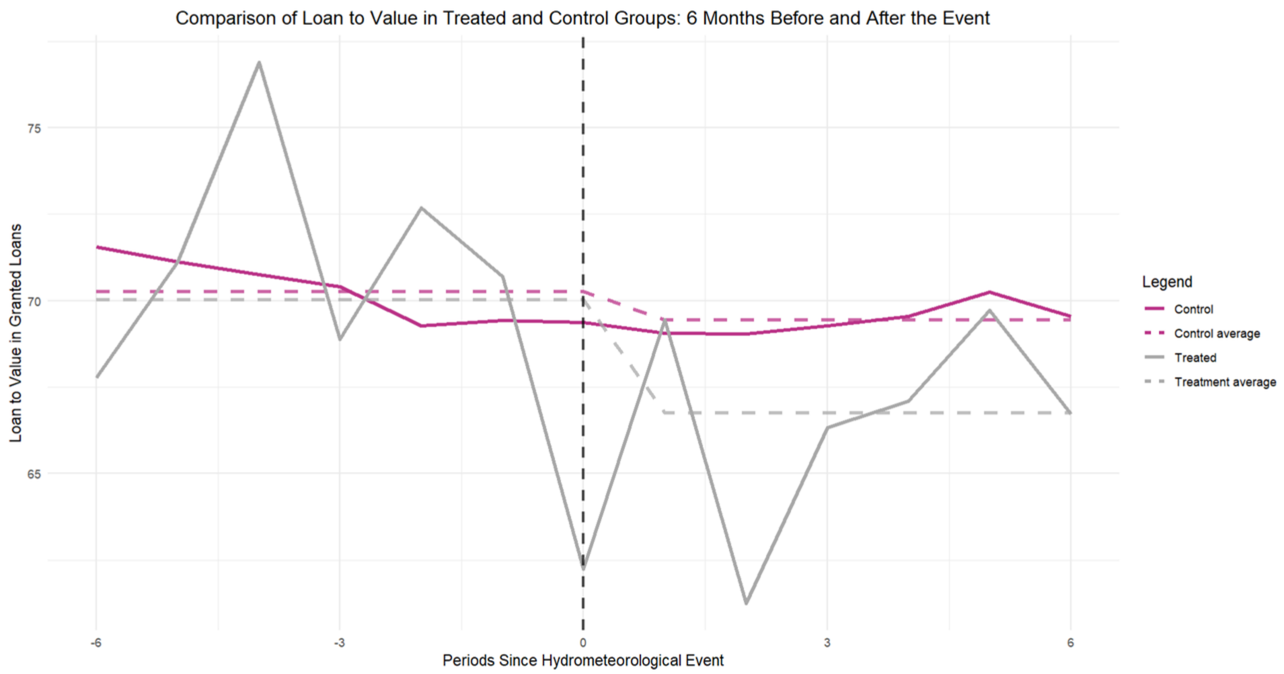
For the exploratory data analysis, we defined the treatment group as the municipalities listed in the emergency declaration database, while the control group consisted of the remaining municipalities, excluding those in Quintana Roo.

Subsequently, we analyzed the trajectories of key quantitative variables of interest in these states over a period of six months before and after the occurrence of the hydrometeorological event. These variables included DTI, LTV, loan amount, loan term, and loan origination costs. However, due to the invariance of the reported interest rate in this context, a similar analysis could not be conducted for this variable.

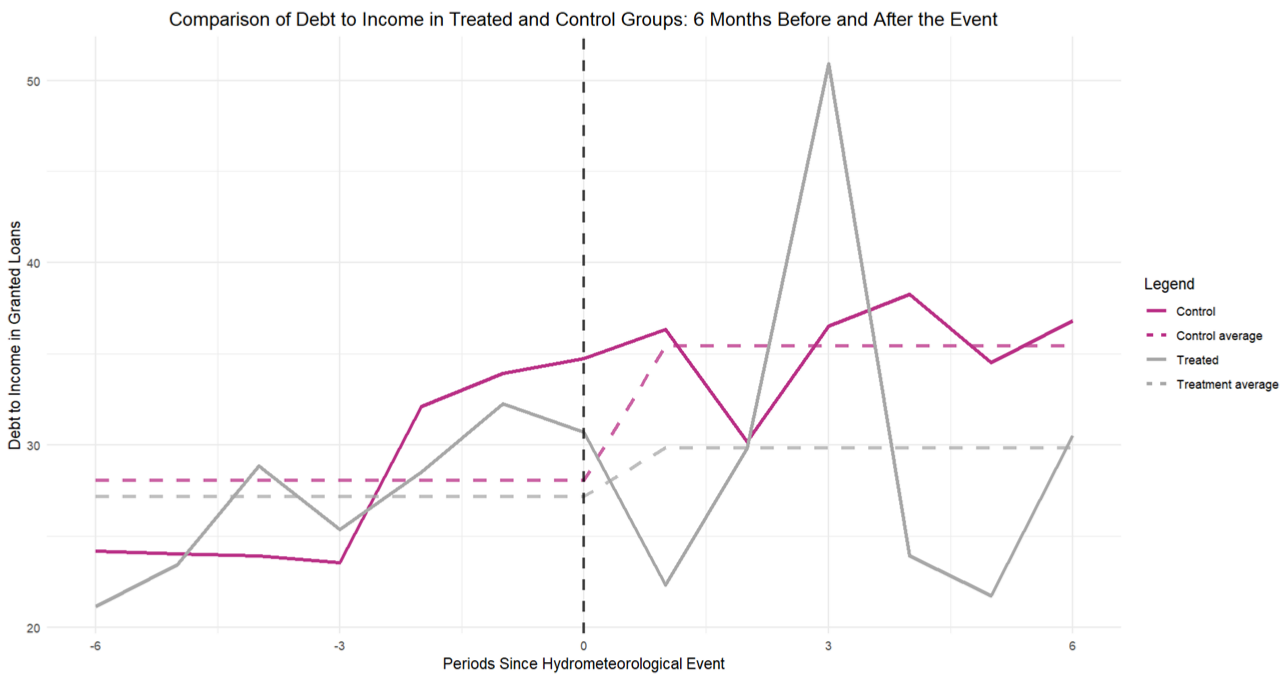
Figure 6: Variables tendencies over time.



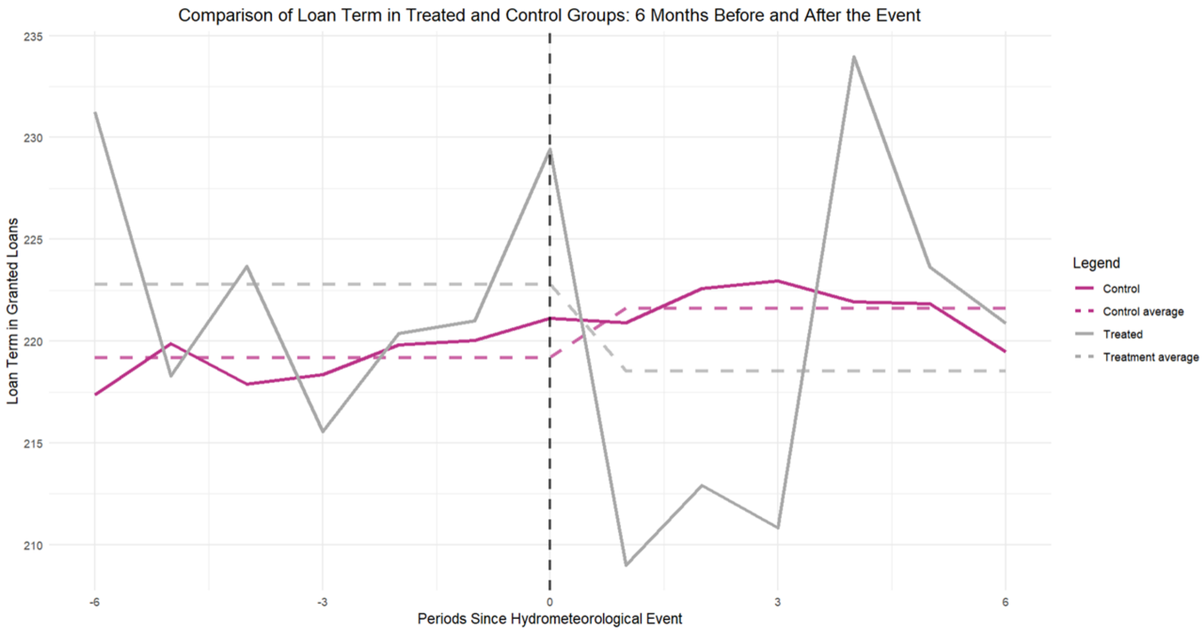
Comparison of Loan Amount in Treated and Control Groups: 6 Months Before and After the Event
Loan Amount in Granted Loans
2500000
2250000
2000000
1750000
1500000
1250000
-6
-3
0
3
6
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average



Comparison of Loan to Value in Treated and Control Groups: 6 Months Before and After the Event
Loan to Value in Granted Loans
75
70
65
-6
-3
0
3
6
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average


Comparison of Debt to Income in Treated and Control Groups: 6 Months Before and After the Event
Debt to Income in Granted Loans
50
40
30
20
-6
-3
0
3
6
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average


Comparison of Origination Fees in Treated and Control Groups: 6 Months Before and After the Event
Origination Fees in Granted Loans
30000
20000
10000
-6
-3
0
3
6
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average



Source: Own elaboration based on data from CENAPRED

A closer examination to these figures reveals multiple findings:

- **Housing Prices:** As shown in the figures, housing prices has more volatility in the treated group than in the control one. However, it is noticeable that the average prices in the periods before and after the event shows a change in the tendency. This suggests that the hydrometeorological event probably caused disruptions in housing demand or supply.

- **Loan Amounts:** In concordance with the housing prices, loan amounts are a result of the movement in prices.

- **LTV:** The variation in the LTV is noticeably higher in the treatment group. Nevertheless, there is a clear general decrease in LTV levels. Furthermore, considering the similarity in average LTVs before the event, the gap between the averages after the event becomes particularly noteworthy.

- **DTI:** The overall behavior of this variable suggests that the smaller increase in the level of indebtedness in the treatment group compared to the control group may reflect risk-adverse measures after the event, considering it as a factor that enhances the probability of default.

- **Origination Fees:** The immediate increase in credit origination costs suggests that lenders raised risk premiums in the region during the initial months following the event, which may have discouraged credit demand. However, this effect appears to be offset over time in relation to other variables.
- **Loan Term:** Following the event, a marked divergence emerges between the treated and control groups. Loan terms in treated regions show significant volatility, with sharp peaks and troughs compared to the relatively steady trends in control regions. This volatility suggests heightened uncertainty in disaster-affected areas, as lenders and borrowers adjust to new risk realities.

4.2 San Luis Potosí Drought

To begin with, it is important to visually identify the regions defined as the treatment group, which consist of several municipalities within the state of San Luis Potosí. Notably, these municipalities represent the main hubs for credit issuance in the state. For the initial data exploration, the remaining municipalities, including those within the same state that were not affected by the event, will be considered as the control group.

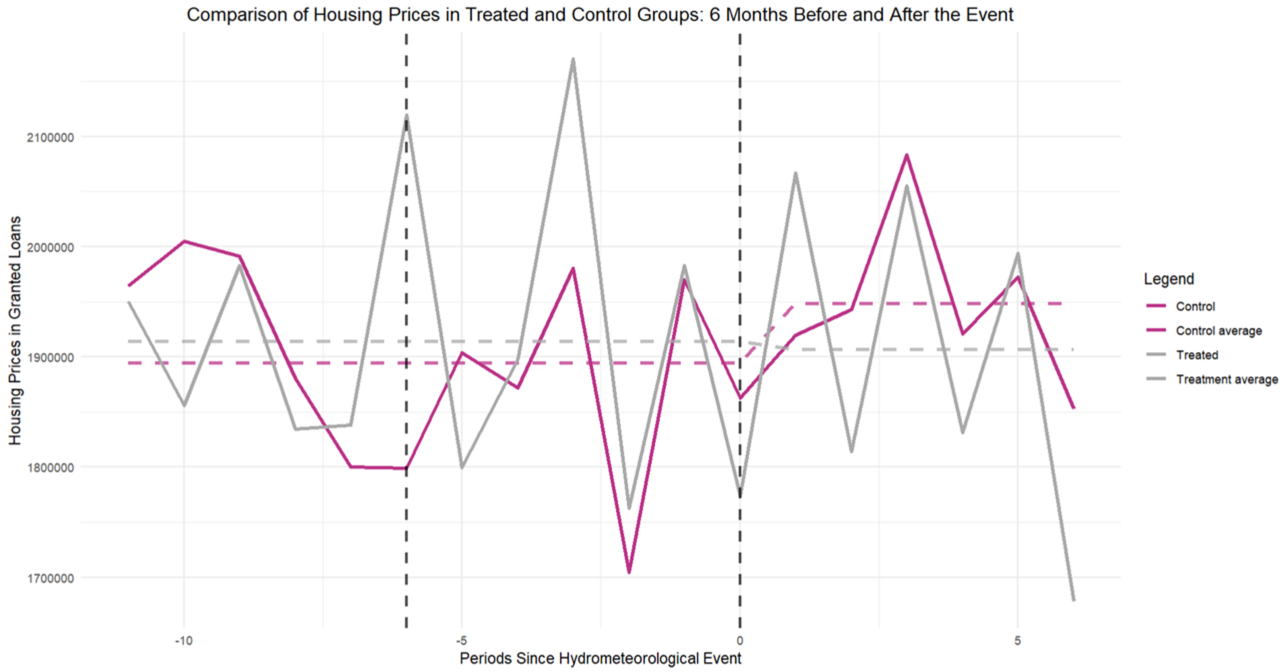
Figure 7: Treated municipalities

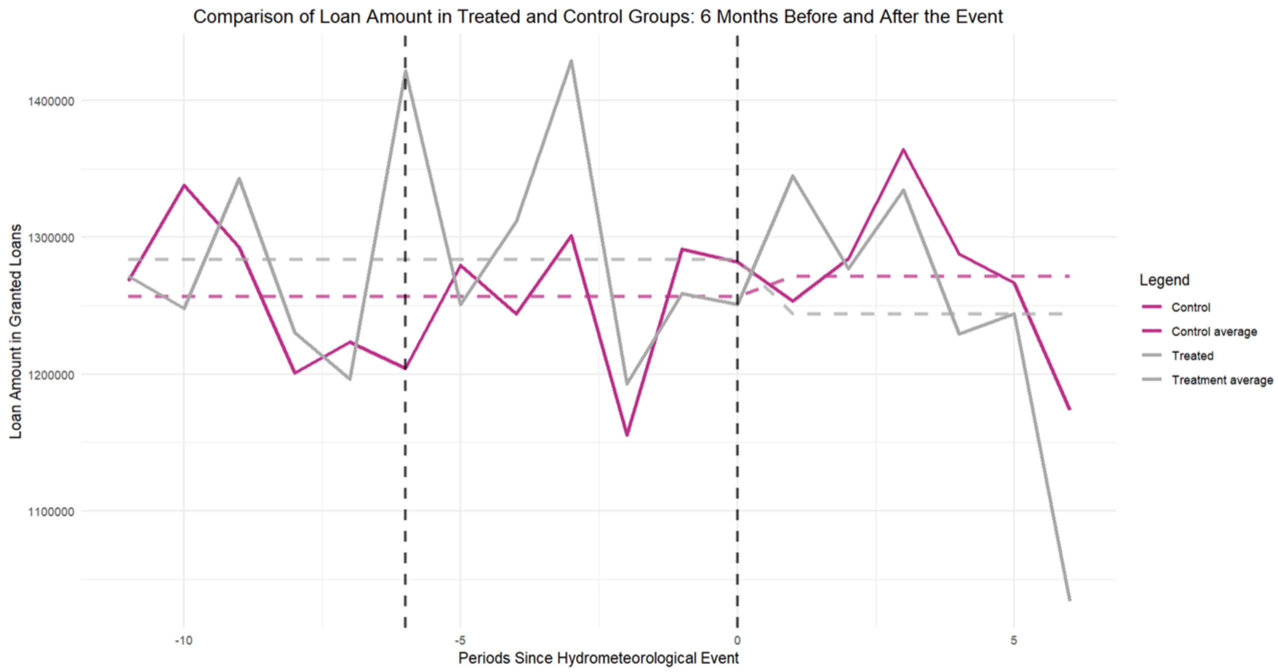
Source: Own elaboration based on data from CENAPRED

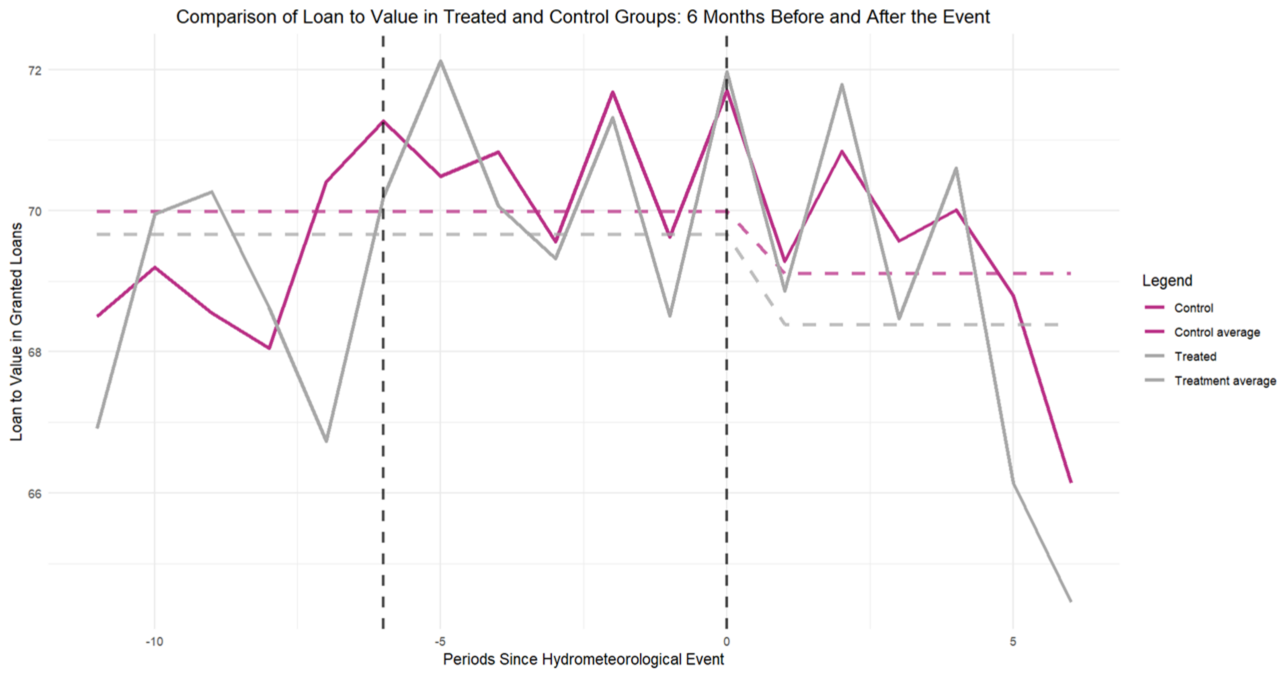
In this section, we analyze the behavior of seven variables of interest related to the event under study. Although the methodological approach employed is similar to that used in hurricane-related analyses, we recognize the fundamental differences between the phenomena. Ideally, the distinct characteristics of each event would warrant a tailored analytical framework. However, due to the methodological and scope constraints of this study, a standardized approach has been adopted. We acknowledge this limitation and its potential impact on the depth of analysis specific to the unique nature of the event.

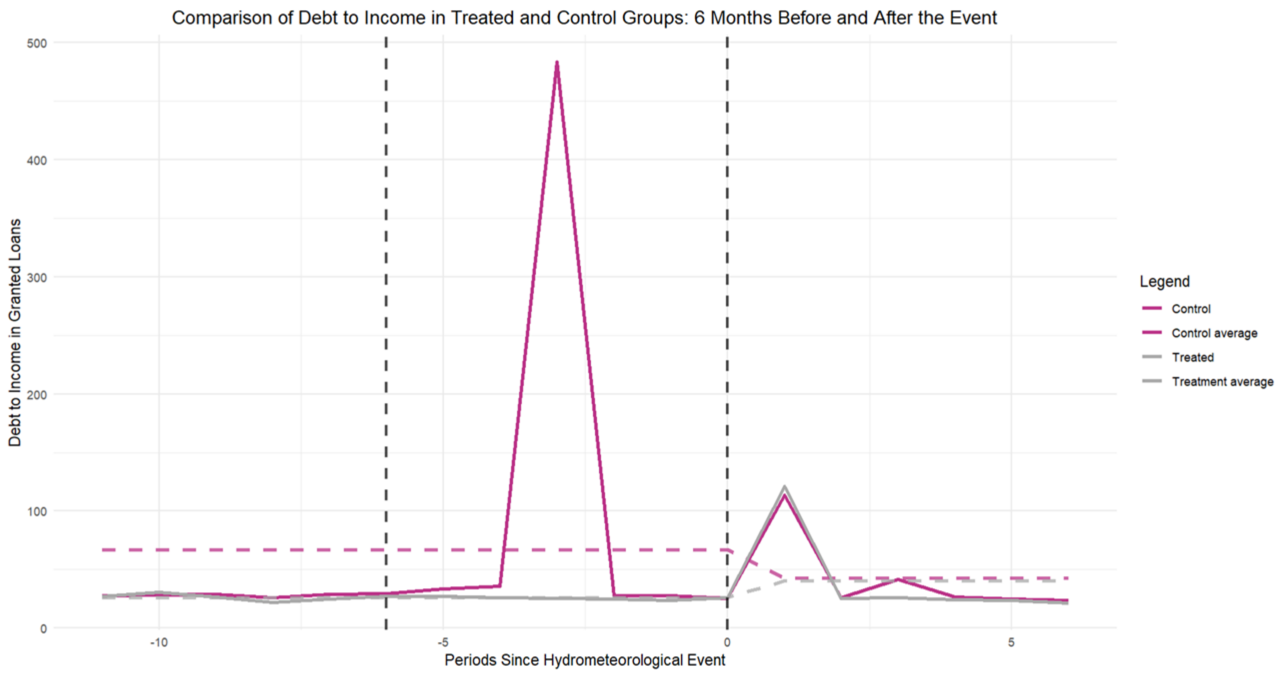
Figure 8: Variables tendencies over time

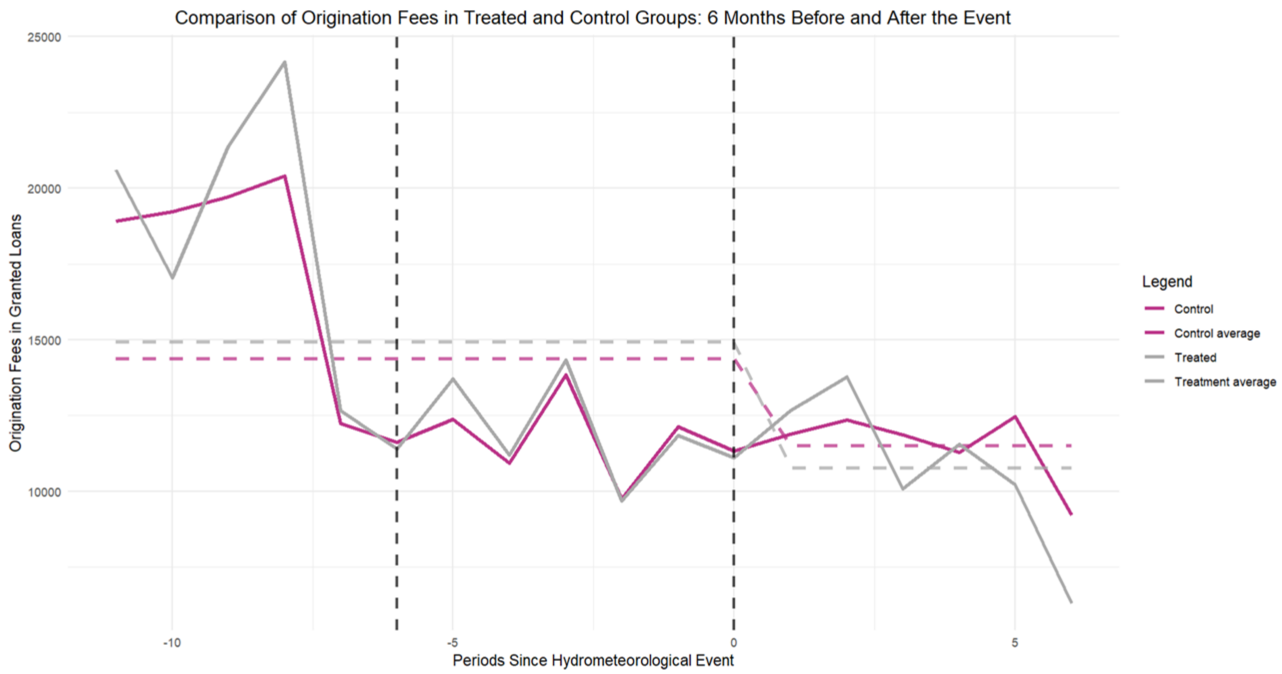
Note: The vertical dashed line on the left indicates the beginning of the drought, while the one on the right marks its conclusion.

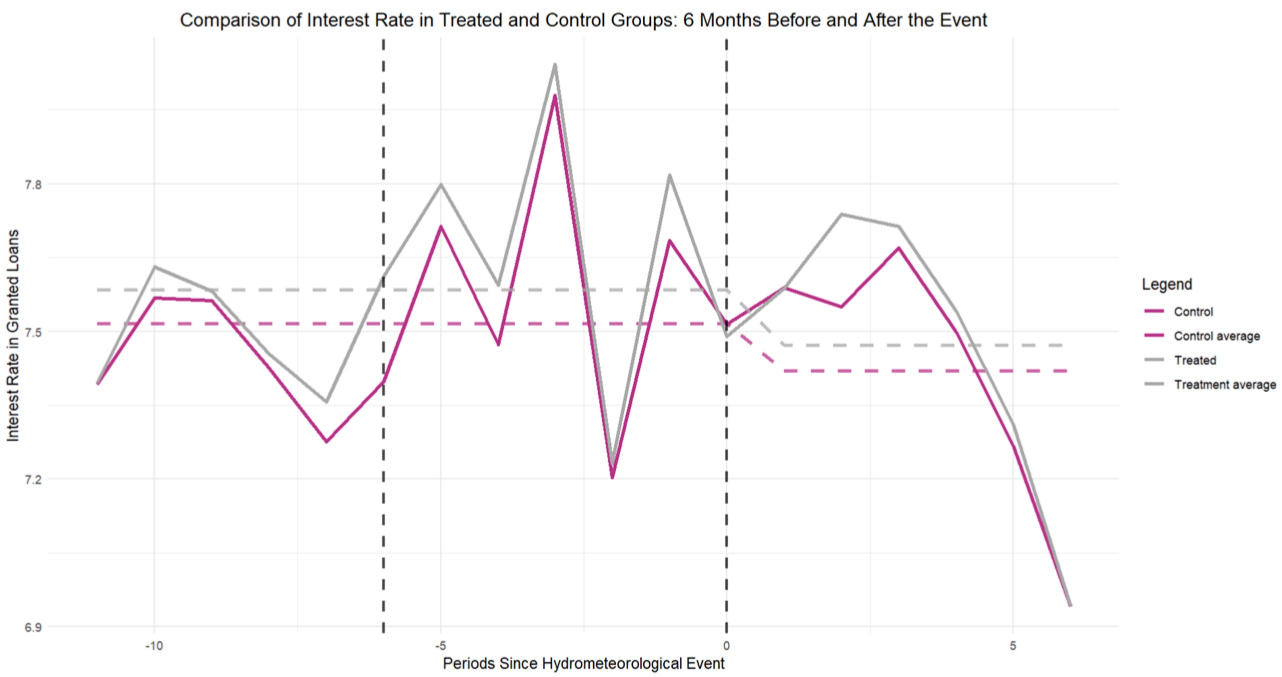


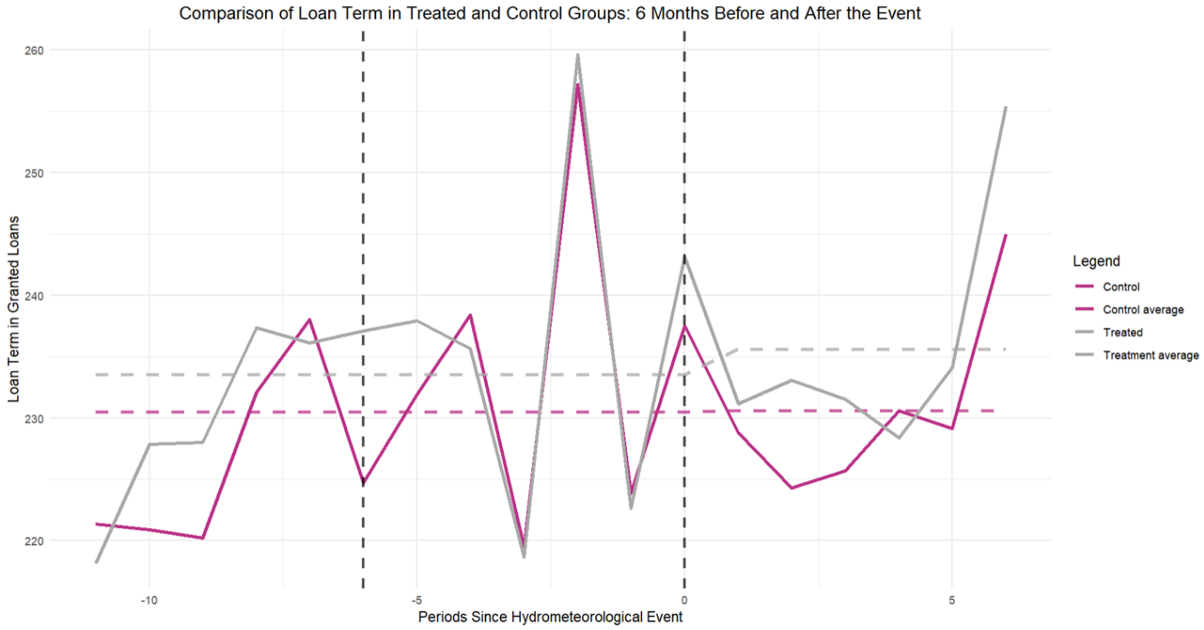



Comparison of Loan to Value in Treated and Control Groups: 6 Months Before and After the Event
Loan to Value in Granted Loans
72
70
68
66
-10
-5
0
5
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average


Comparison of Debt to Income in Treated and Control Groups: 6 Months Before and After the Event
Debt to Income in Granted Loans
500
400
300
200
100
0
-10
-5
0
5
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average


Comparison of Origination Fees in Treated and Control Groups: 6 Months Before and After the Event
25000
20000
15000
10000
Origination Fees in Granted Loans
-10
-5
0
5
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average


Comparison of Interest Rate in Treated and Control Groups: 6 Months Before and After the Event
7.8
7.5
7.2
6.9
Interest Rate in Granted Loans
-10
-5
0
5
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average



Source: Own elaboration based on data from CENAPRED

The areas of interest of this figures can be resumed as followed:

- **Housing prices:** During the drought, housing prices show increased volatility and pronounced spikes. After the drought ends, there is a noticeable decline in average housing prices in the treated group, contrasting with stable trends in the control group. This suggests the drought had a localized impact on the housing market.
- **Loan Amount:** In concordance with the housing prices, loan amounts are a result of the movement in prices.
- **LTV:** Midway through the drought, the control and treated group acquire the same pattern but in different magnitudes. In one hand, a parallel tendency appears, but in the other a more pronounced decrease is shown in the treated group which can be interpred as the effect of the drought.
- **DTI:** This variable is remarkably similar between treated and control groups throughout the time, suggesting that lenders did not significantly alter their practices in response to the drought
- **Origination Costs:** In this variable it is easy to perceive the parallelism in the behavior of the variable just before the end of the drought. After that is very interesting to see the differences in the first periods. The natural assumption for this is that lenders increase the risk premium in the origination fees.
- **Interest rate:** This variable shows a parallel tendency in the two groups analyzed. However, in period one and two it is notable the opposite direction in interest rate trajectory in the treated group most likely because of risk premiums also inserted in the interest rate.
- **Loan Term:** This variable shows a change in behavior very visible after the end of the drought period and its notably higher in the treated than the control group. This can be an effort to balance the effect in demand of the increase in risk premia.

4.3 Hurricane Otis

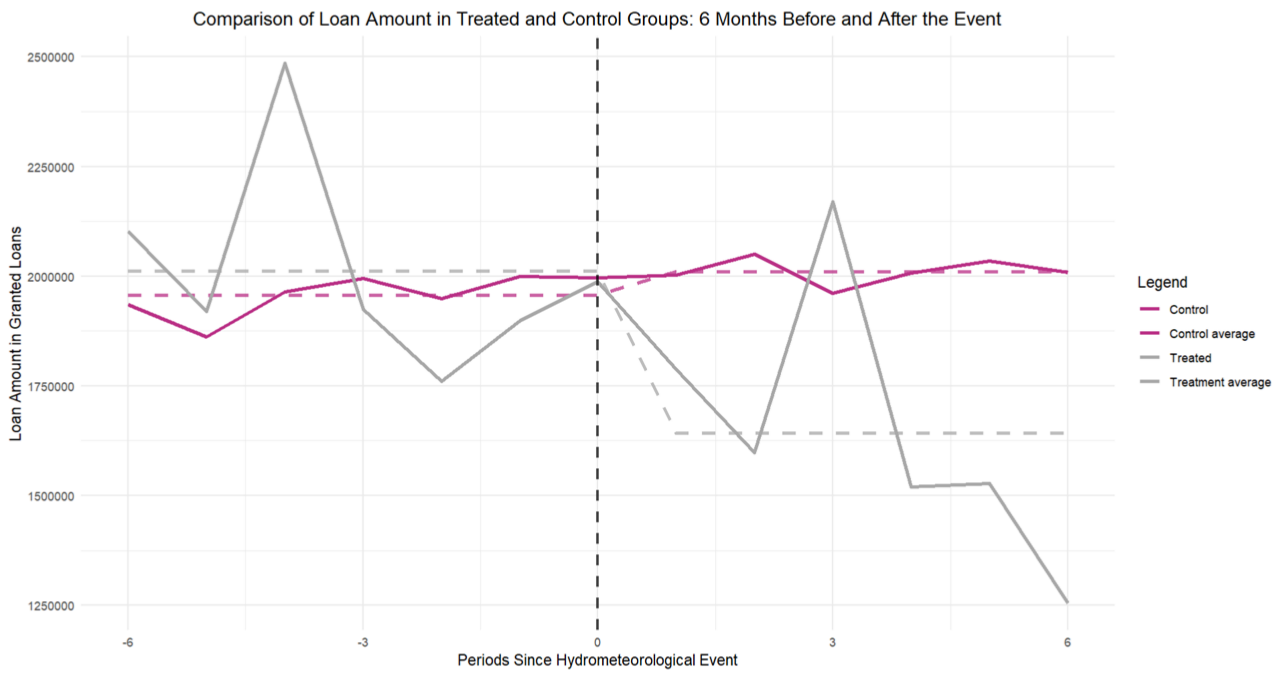
Finally, in this section we present the findings of one of the most devastating hurricanes in Mexico that took place recently, in October 2023.

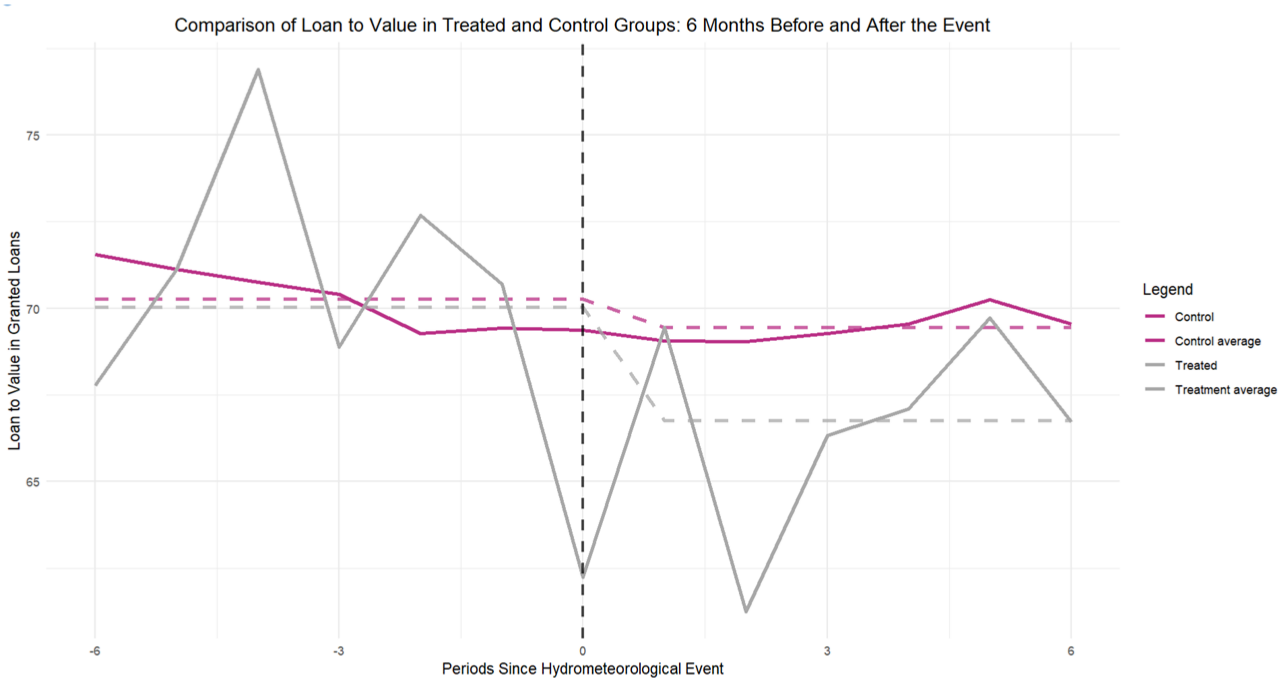
Figure 9: Treated states

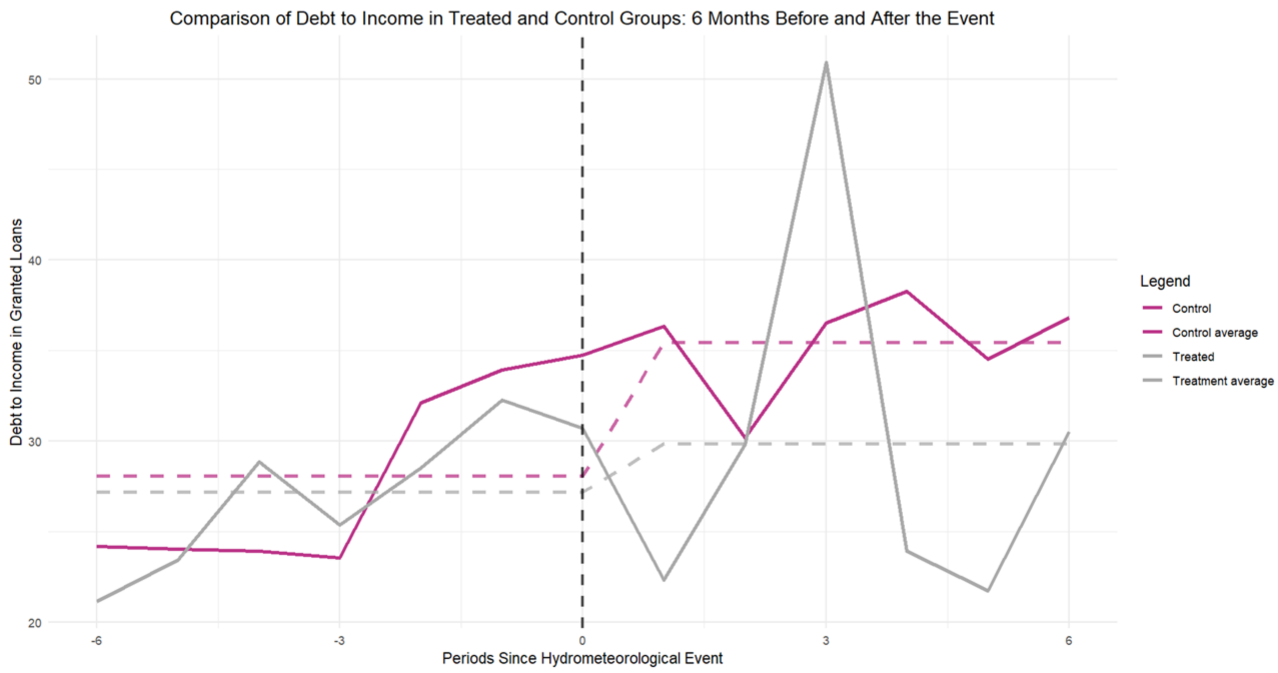
Source: Own elaboration based on data from CENAPRED

Although the hurricane affected fewer areas across the republic, the intensity and prolonged duration of the winds in the state of Guerrero caused significant damage to local infrastructure. For this analysis, we examine six variables of interest, defining the treated group as the municipalities directly impacted by the hurricane and the control group as the remaining municipalities, including those within the same state that did not experience the effects of this phenomenon.

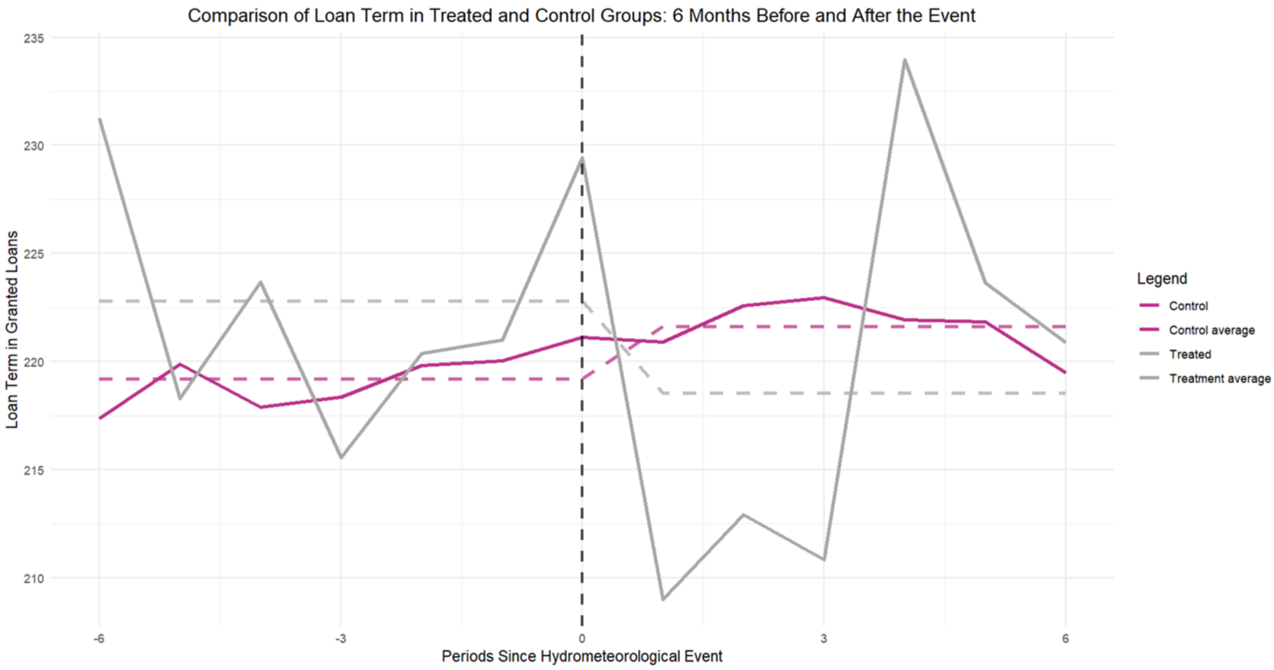
Figure 10: Variables tendencies over time


Comparison of Loan Amount in Treated and Control Groups: 6 Months Before and After the Event
2500000
2250000
2000000
1750000
1500000
1250000
Loan Amount in Granted Loans
-6
-3
0
3
6
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average


Comparison of Loan to Value in Treated and Control Groups: 6 Months Before and After the Event
75
70
65
Loan to Value in Granted Loans
-6
-3
0
3
6
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average


Comparison of Debt to Income in Treated and Control Groups: 6 Months Before and After the Event
Debt to Income in Granted Loans
50
40
30
20
-6
-3
0
3
6
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average


Comparison of Origination Fees in Treated and Control Groups: 6 Months Before and After the Event
Origination Fees in Granted Loans
30000
20000
10000
-6
-3
0
3
6
Periods Since Hydrometeorological Event
Legend
Control
Control average
Treated
Treatment average



Source: Own elaboration based on data from CENAPRED

A detailed review of these figures uncovers several key insights:

- **Housing Prices:** The treated group exhibits significant volatility in housing prices before and after the hydrometeorological event, in contrast to the more stable patterns observed in the control group. The sharp declines in the treated average immediately post-event indicate a disruption in the housing market dynamics, likely driven by heightened uncertainty or reduced demand in affected areas.

- **Loan Amounts:** Loan amounts in the treated group show pronounced fluctuations, particularly following the event, with a steep decline and subsequent recovery. The control group, on the other hand, maintains relatively consistent levels. These trends suggest that the event introduced considerable uncertainty in lending activity for the treated regions, potentially altering both supply and demand for credit.

- **Loan to Value (LTV):** The LTV ratio for the treated group shows notable instability, including a sharp spike prior to the event and a marked decrease afterward. While the control group exhibits a steady trend, the divergence between treated and control averages post-event suggests a shift in risk assessment and lending conditions in affected areas.

- **Debt to Income (DTI):** The DTI ratio rises significantly in the treated group following the event, peaking well above the control group. This indicates increased financial strain among borrowers in the treated regions, possibly reflecting higher credit demand relative to income or stricter lending standards imposed by financial institutions.

- **Origination Fees:** Origination fees for the treated group decline sharply after the event, diverging from the relatively stable trajectory observed in the control group. This suggests that lenders may have adjusted fee structures in the treated regions to stimulate credit demand or account for changing market conditions in disaster-affected areas.

- **Loan Term:** The treated group demonstrates considerable volatility in loan terms, with abrupt increases and decreases surrounding the event period. In contrast, the control group maintains a more stable pattern. This discrepancy highlights the dynamic adjustments made by lenders and borrowers in the treated regions in response to increased uncertainty and perceived risks post-event.

5 Methodology

To verify the existence of causality between the occurrence of a hydrometeorological event and changes in credit granting conditions, we will use a synthetic control model that we will specify in detail below. We define the physical shock as described above and identify treatment regions as municipal units that were affected by the phenomenon. Likewise, we select only those with at least the average number of credit granting of the state in which they are located on a monthly basis.

With this information, we will have $i, i = 1, ..., 33$ sample units that summarize the information contained per credit in states. It should be noted that, although there are only 32 states in the Mexican Republic, the municipalities affected by the hurricane are separated from the others in the same state, so the units treated will be the 33th unit.

In addition, T_0 is defined as the time of treatment. We possess information on the actual path of 6 variables: DTI, LTV, loan amount, term and origination costs ($Y_{33t,j}$, $\quad t > T_0$ and variable j from the aforementioned list) . However, the counterfactual paths of the same variables if the hurricane had not occurred are unknown ($Y^N_{33t,j}$, $\quad t > T_0$ and variable j from the aforementioned list). Therefore, we seek to find an estimate of $Y^N_{33t,j}$ to obtain an estimate of the treatment effect *(te)*:

$$\pi_{33t,j} = Y_{33t,j} - Y^N_{33t,j} \tag{1}$$

And the average treatment effect *(ate)* for all estimated periods $T_0 \leq t \leq T$

$$\bar{\pi_{33,j}} = \frac{\sum_{t\,=\,T_0}^{T} \pi_{33t,j}}{T - T_0} \tag{2}$$

Abadie and Gardeazabal (2003), Abadie et al. (2010) and Abadie et al. (2015) suggest that, from the unaffected states and municipalities, one should find weights $W = (w_1, ..., w_{32})'$ such that:

$$\sum_{i=1}^{32} w_i = 1 \tag{3}$$

So, the average of the control municipalities resembles the treated ones with respect to each of the described variables (independently) and the remaining characteristics (Z).

Formally, we look for W such that:

$$\sum_{i=1}^{32} w_j * Y_{it,j} = Y_{33t,j} \qquad \forall \sum_{i=1}^{32} w_j * Z_{i,j} = Z_{33,j} \tag{4}$$

Then:

$$\hat{Y_{33t,j}^{N}} = \sum_{i=1}^{32} w_j \ Y_{it,j} \tag{5}$$

It is an estimate for the unobserved counterfactual trajectories of $Y_{33t,j}^{N}$ that induces an estimate of the treatment effect:

$$\hat{\pi}_{33t,j} = \ Y_{33t,j} - \sum_{i=1}^{32} w_j \ Y_{it,j} \ , \quad t \ \geq T_0 \tag{6}$$

Then we can define an estimate for the average treatment effect:

$$\hat{\hat{\pi_{33,j}}} \ = \frac{\sum_{t \ = \ T_0}^{T} \hat{\pi_{33t,j}}}{T - T_0} \tag{7}$$

In general, a vector W that satisfies the conditions in equation (4) may not exist. However, we can define the minimization problem that solves it.

$$\min_{W} \qquad (X_1 - X_0 W)' V (X_1 - X_0 W) \tag{8}$$

Where X_1 denotes a vector of $(k * 1)$ preintervention characteristics of the treated state, which may include the preintervention trajectory and X_0 denotes a matrix $(k * j)$ of the same variables for j states in the donor group. The symmetric and positive defined matrix V weights the relative importance of the various characteristics included in X. The optimal weights X depend on the weighting matrix V. For the estimations, we follow Abadie et al. (2010) by choosing V using a regression-based method and equal weights.

6 Results

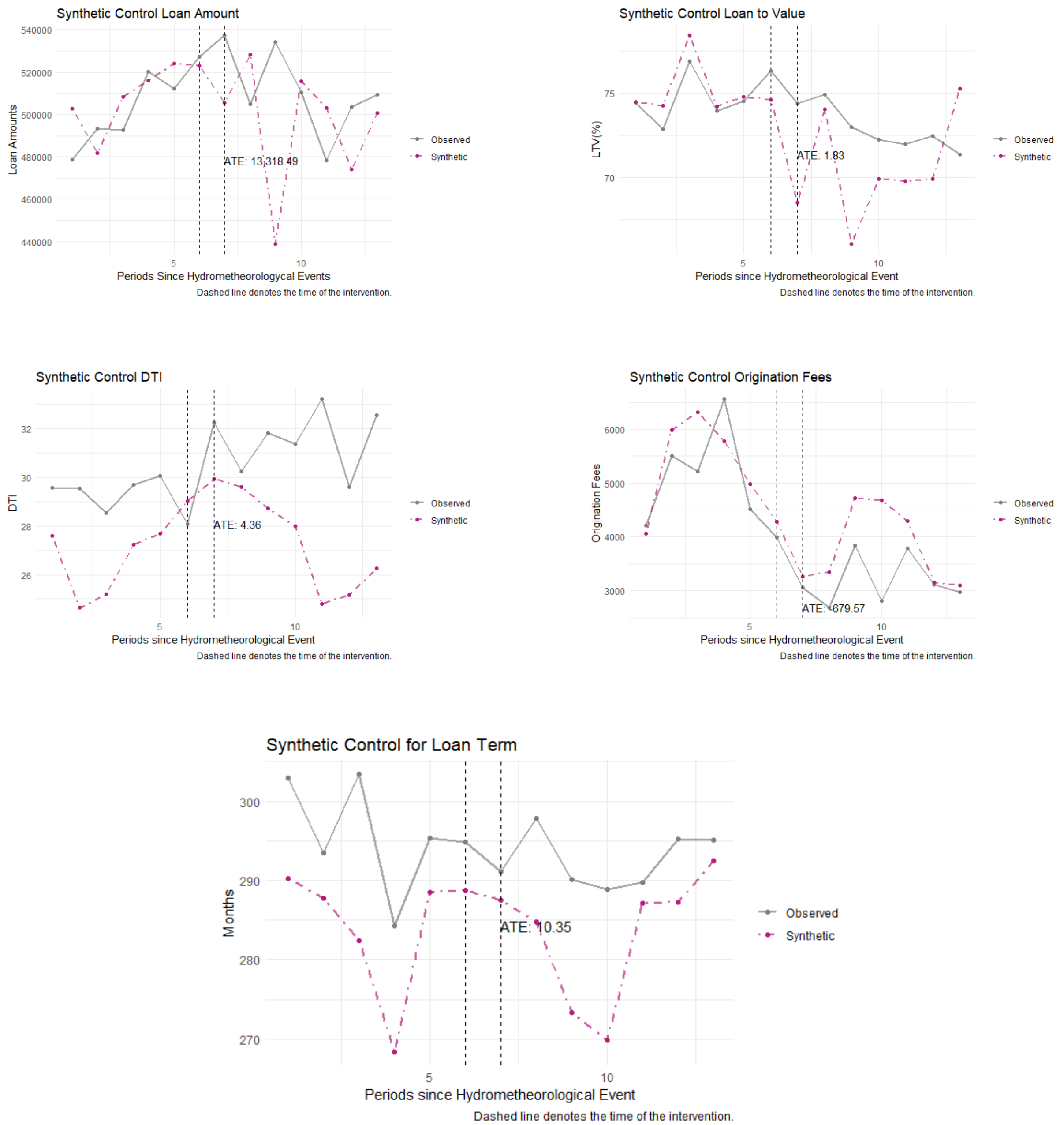
6.1 Hurricane Alex

For this case, Table A shows the weights that helped to construct the synthetic control for each of the variables. Table 1 indicates the treatment effects for each of the variables and for the previous and subsequent periods of the hurricane. Also, the images in Figure 11 present visual evidence of the efects.

Table 1: Treatment effect in periods since event $real - synth$

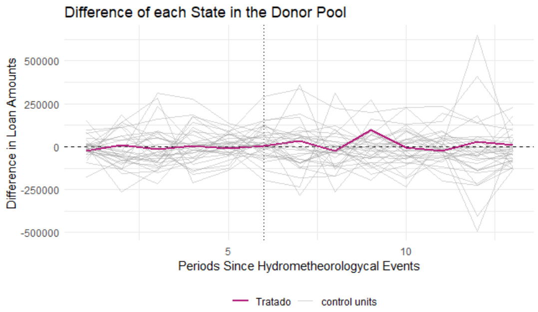
Periods After Event	**Loan Amount**	**LTV**	**DTI**	**Origination Fees**	**Loan Term**
1	-23,101.839	0.876	0.643	-652.247	13.067
2	95,209.368	6.917	3.094	-879.330	16.871
3	-5,404.167	2.324	3.359	-1876.823	19.000
4	-24,592.047	2.192	8.386	-508.477	2.555
5	29,116.361	2.556	4.415	-38.380	7.996
6	8,683.290	-3.885	6.286	-122.152	2.617
ATE post	**13,318.495**	**1.830**	**4.363**	**-679.568**	**10.350**

Figure 11: Trajectories in synthetic control and observed groups

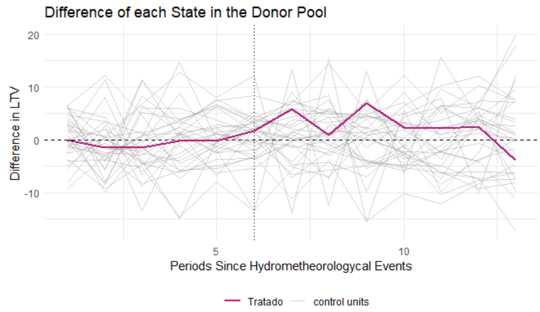


To strengthen the information, we now present placebo plots for each of the variables. In these, we intend to find that the results are not random fluctuations.

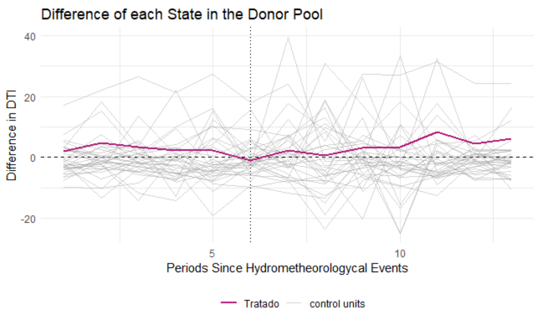
Figure 12: Placebo test



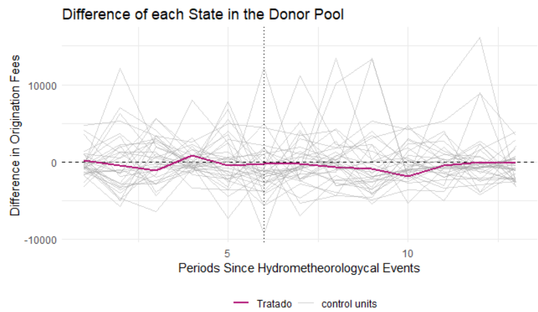
(a) Loan Amount



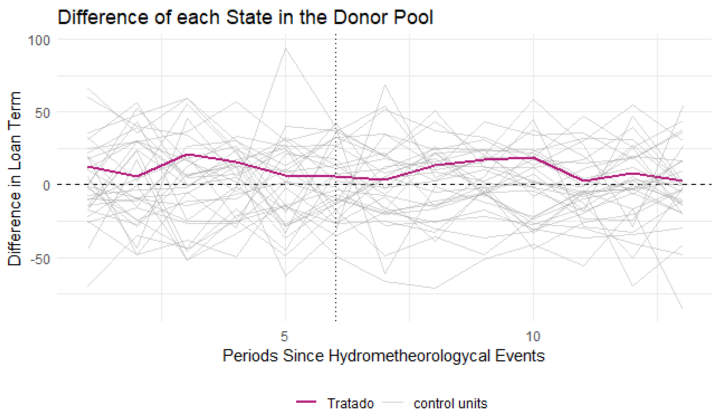
(b) LTV



(c) DTI



(d) Origination Fees



(e) Loan Term

6.2 San Luis Potosí Drought

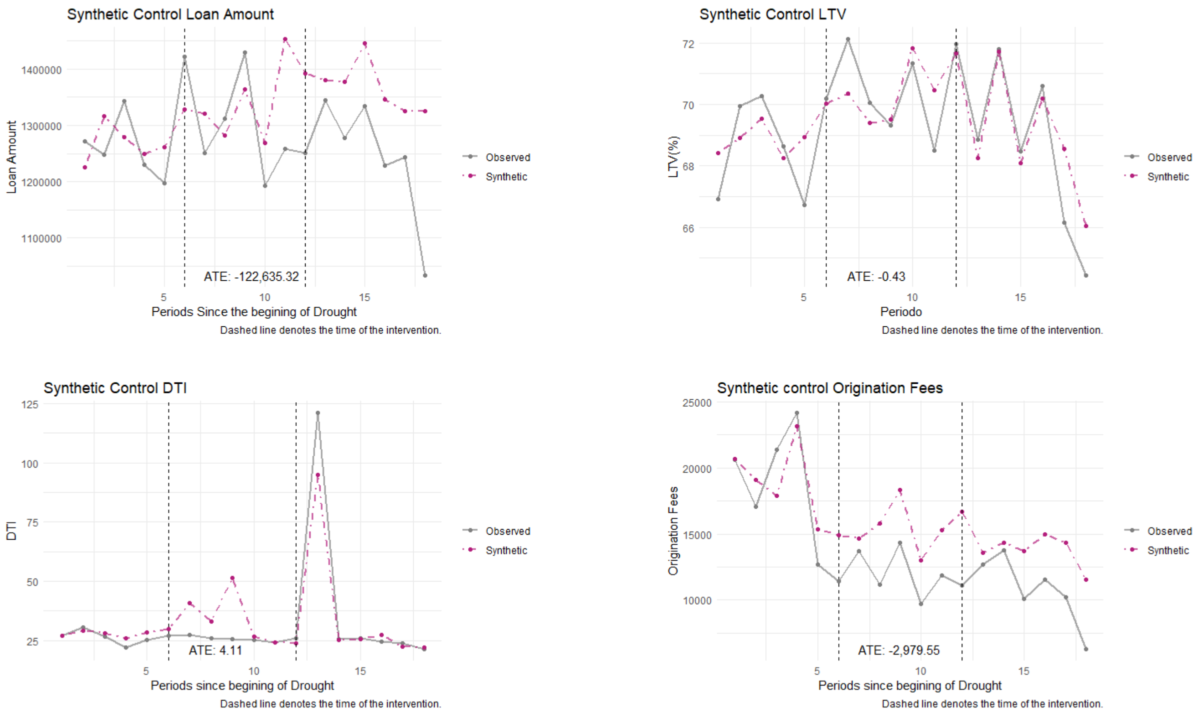
Table B exhibits the weights that helped to construct the synthetic control for each of the variables. Table 2 depicts the treatment effects for each of the variables and for the previous and subsequent periods of the hurricane. Also, the images in Figure 13 present visual evidence of the efects.

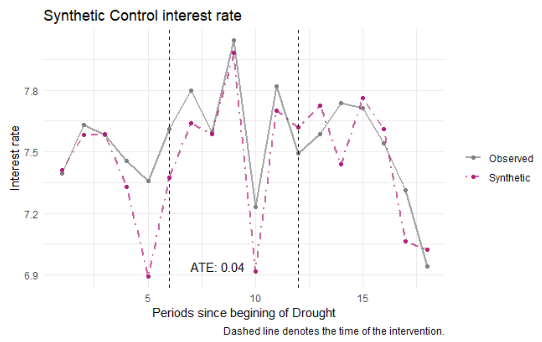
Table 2: Treatment effect Since Beginning of Drought

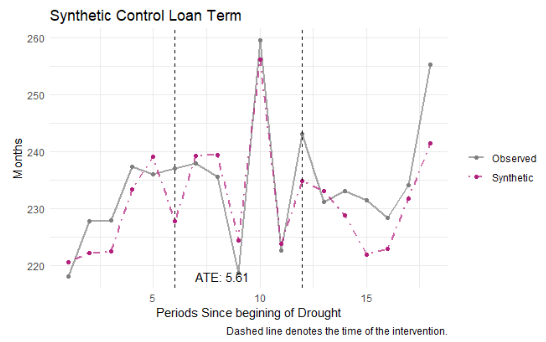
Periods Since Beginning of Drought	Loan Amount	LTV	DTI	Origination Fees	Interest Rate	Loan Term
1	29,929.83	0.67	-7.01	-4,625.25	0.01	-3.84
2	64,173.39	-0.20	-25.67	-3,991.28	0.06	-5.80
3	-74,823.15	-0.51	-1.69	-3,345.51	0.32	3.33
4	-193,784.24	-1.97	-0.18	-3,485.29	0.12	-1.23
5*	-140,512.12	0.31	2.12	-5,615.61	-0.13	8.30
6	-35,242.52	0.60	25.96	-917.82	-0.14	-2.00
7	-99,866.97	0.07	0.52	-539.93	0.30	4.26
8	-111,240.35	0.37	0.59	-3,618.92	-0.05	9.63
9	-116,414.75	0.40	-2.87	-3,433.30	-0.07	5.45
10	-81,982.01	-2.41	1.11	-4,119.10	0.25	2.37
11	-291,065.30	-1.59	-0.68	-5,248.21	-0.08	13.95
ATE	**-122,635.32**	**-0.43**	**4.11**	**-2,979.55**	**0.04**	**5.61**

The period with * represent the end of the drought.

Figure 13: Trajectories in Synthetic Control and Observed Groups

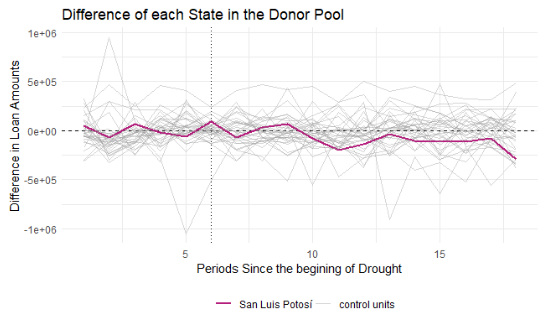




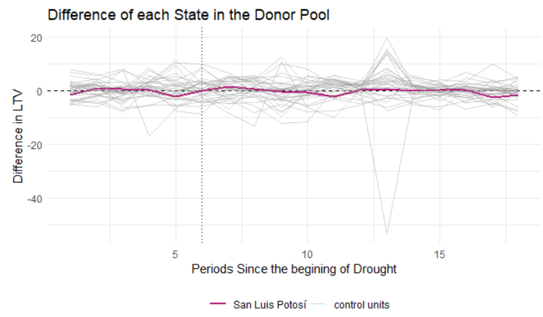


To strengthen the information, we now present placebo plots for each of the variables. In these, we intend to find that the results are not random fluctuations.

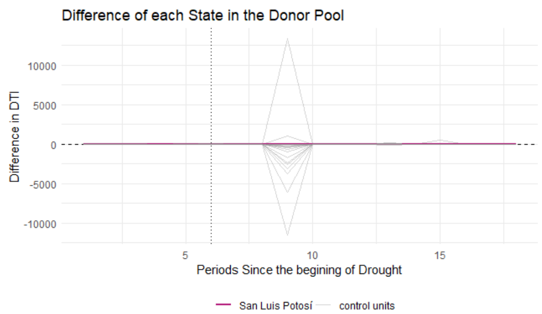
Figure 15: Placebo Test



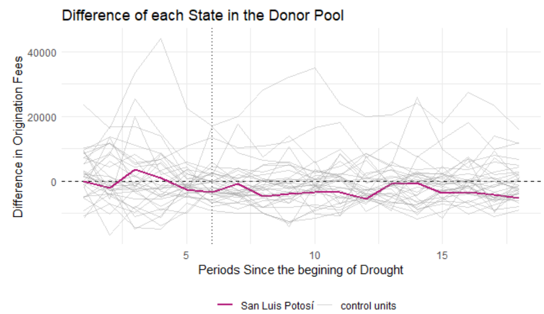
(a) Loan Amount



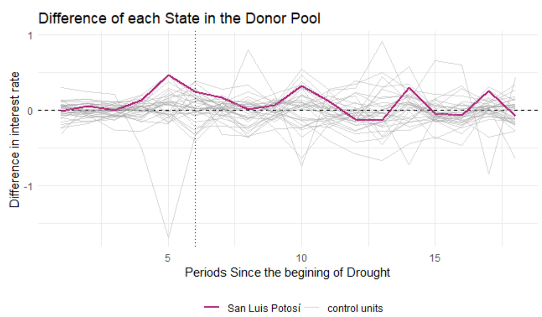
(b) LTV



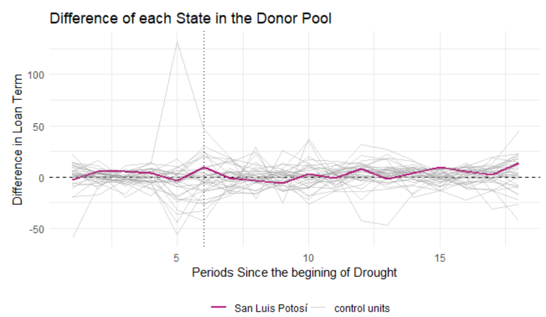
(c) DTI



(d) Origination Fees



(e) Interest Rate



(f) Loan Term

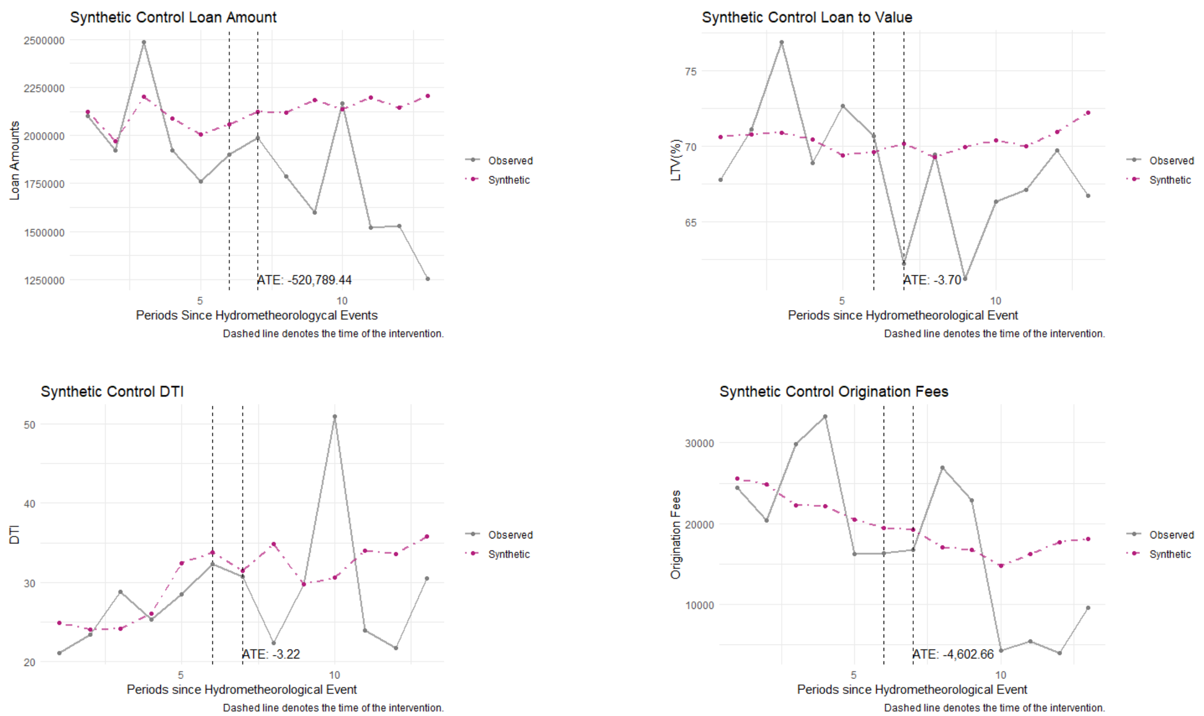
6.3 Hurricane Otis

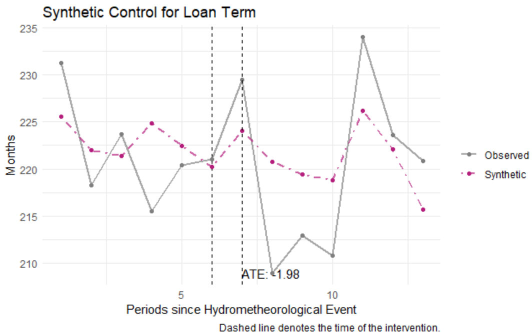
For this case, Table C displays the weights that helped to construct the synthetic control for each of the variables. Table 3 represents the treatment effects for each of the variables and for the previous and subsequent periods of the hurricane. Also, the images in Figure 16 present visual evidence of the effects.

Table 3: Treatment Effects Since Event

Periods Since Event	Loan Amount	LTV	DTI	Origination Fees	Loan Term
1	-328,293.888	0.187	-12.469	9,866.074	-11.807
2	-586,586.943	-8.713	0.064	6,147.005	-6.500
3	33,023.436	-4.057	20.247	-10,519.351	-7.999
4	-675,455.248	-2.887	-10.060	-10,783.626	7.778
5	-616,912.770	-1.262	-11.837	-13,711.401	1.538
6	-950,511.239	-5.498	-5.242	-8,614.685	5.119
ATE post	**-520,789.442**	**-3.705**	**-3.216**	**-4,602.664**	**-1.978**

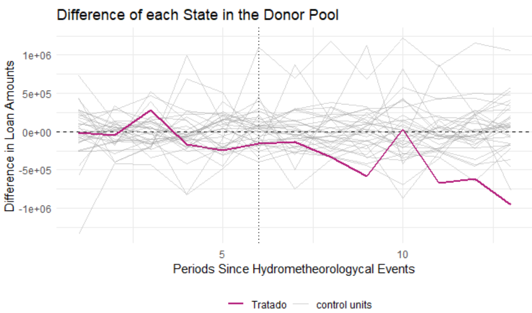
Figure 16: Trajectories in Synthetic Control and Observed Groups



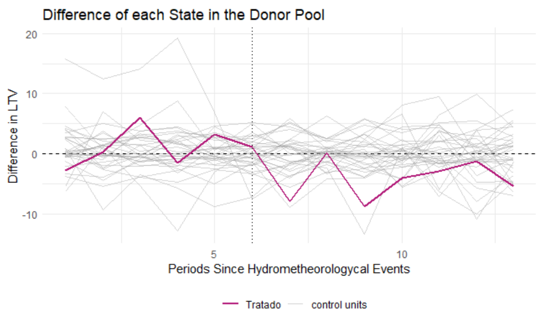


To strengthen the information, we now present placebo plots for each of the variables. In these, we intend to find that the results are not random fluctuations.

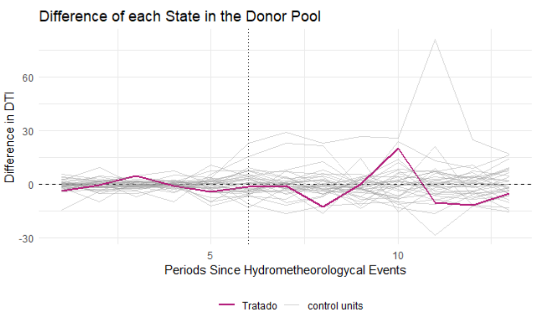
Figure 17: Placebo Test



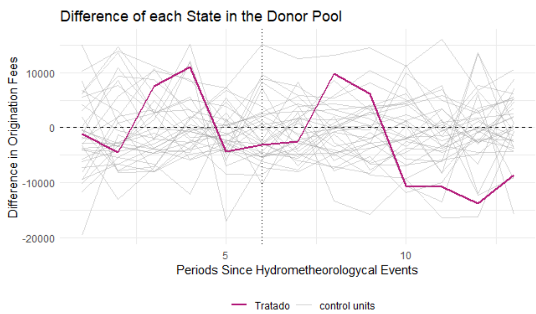
(a) Loan Amount



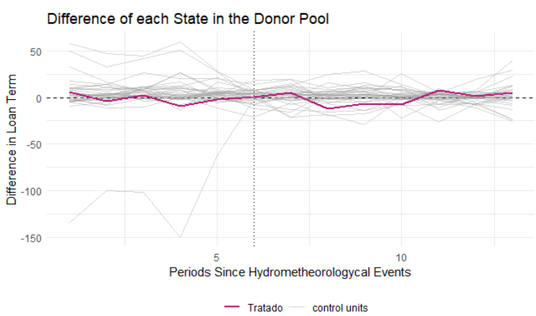
(b) LTV



(c) DTI



(d) Origination Fees



(e) Loan Term

7 Discussion

This study evidence how physical climate shocks, such as hurricanes and droughts, significantly impact mortgage credit conditions in Mexico. Through a detailed analysis based on the synthetic control method, we have been able to identify specific changes in key variables such as loan amount, LTV, DTI, origination costs and loan terms. This section discusses the most relevant findings in depth, linking them to the financial and socioeconomic implications and highlighting the importance of the results obtained in the placebo analysis to validate that the observed effects are not the product of chance.

In the case of hurricanes such as Alex and Otis, immediate and profound effects on mortgage credit conditions were detected. One of the most striking observations is the behavior of the loan amount, which showed an initial increase after the event, followed by an abrupt decrease in subsequent periods. This suggests that banks initially try to maintain funding levels to avoid an immediate economic contraction, but then adopt restrictive measures to mitigate the risk of default. The data from the placebo units reinforce the validity of this finding, as they do not show similar patterns in the untreated regions, confirming that these fluctuations are specific to hurricane-affected areas.

The LTV showed a clear downward trend in the treated areas, reflecting the fact that banks require higher up-front contributions from borrowers. This adjustment responds to the need to reduce their risk exposure in an environment where property values may be affected by hurricane damage. The placebo data, again, show that this effect is not generalized, but exclusive to the treated units. The implications of this trend are significant, as it hinders access to credit for vulnerable populations in affected areas, exacerbating economic inequalities.

Regarding the DTI, our analysis revealed a significant increase following hurricanes, suggesting that households in the affected regions assumed a higher debt burden relative to their income. This trend can be attributed to borrowers' need to finance repairs or cover unforeseen expenses resulting from the weather event. The placebo tests confirm that this increase is unique to the treated units, thereby validating the direct relationship between the event and the rise in DTI. Nevertheless, this shift also presents a considerable challenge, as it heightens the risk of defaults, potentially jeopardizing the financial stability of banks

A similar effect is seen in origination costs, which increased significantly in the regions discussed. This adjustment reflects an attempt by banks to pass on the cost of additional risk to borrowers, allowing them to maintain the viability of their operations in a context of greater uncertainty. The placebo data show stability in this variable for unaffected regions, reinforcing the idea that the increase in origination costs is directly linked to weather events. However, this strategy has a considerable socioeconomic impact, as it raises entry barriers for households seeking access to mortgage financing.

Finally, the loan term was reduced in the treated regions, suggesting that banks are less willing to commit to long-term loans in areas vulnerable to natural disasters. This adjustment can be interpreted as a precautionary measure in the face of uncertainty about the long-term economic stability of these regions. The placebos, again, show stability in this variable, validating that this reduction is a direct response to the hurricanes. While this measure may be financially prudent, it limits financing options for borrowers, forcing them to accept less favorable terms.

In contrast to the acute effects of hurricanes, the results for the drought in San Luis Potosí evidence a more gradual and sustained pattern. The loan amount showed a progressive decrease, suggesting a cumulative risk perception on the part of the banks. Unlike hurricanes, droughts generate a less immediate impact, but their effects extend over time, affecting credit conditions in a structural way. The placebo data show that this behavior is not observed in unaffected regions, which confirms the direct relationship between drought and the contraction in credit amounts.

In terms of LTV, the drought also led to a slight decrease in this variable, reflecting a conservative adjustment by banks. Although this change is less pronounced than in the case of hurricanes, it is still significant, as it indicates a gradual increase in initial contribution requirements. The placebos, once again, confirm that this effect is unique to drought-affected regions. Similarly, the DTI increased gradually, which is evidence of how households in affected areas face greater financial pressure over time. This effect, validated by placebos, suggests that droughts impose sustained economic challenges on affected communities.

In terms of origination costs, droughts present an interesting contrast to hurricanes. In this case, costs tend to decrease slightly, which could be interpreted as an attempt by banks to encourage lending in chronically affected regions. This finding, validated by placebos, reflects a differentiated strategy in the face of acute and chronic climate shocks. Finally, loan terms in drought-affected regions remained relatively stable, with slight reductions in recent periods. This indicates that banks do not perceive the same level of long-term risk in these areas as they do in the case of hurricanes.

In summary, the results of the placebo analysis are fundamental in confirming that the effects observed in the treated regions are not the product of chance. The stability in the key variables for the placebo units validates the hypothesis that the changes observed in the treated units are specific responses to climatic events. This finding reinforces the robustness of the synthetic control model and highlights the importance of adopting differentiated approaches to mitigate the financial risks associated with different types of climate shocks.

8 Conclusions

This study provides compelling evidence of the varied impacts of physical climate shocks on mortgage lending conditions in Mexico, emphasizing the nuanced responses of financial institutions to different climatic events. Hurricanes, such as Alex and Otis, elicit immediate and acute adjustments in lending practices, characterized by increased origination fees, reduced LTV ratios, and shorter loan terms, reflecting heightened risk aversion. In contrast, droughts, like the one in San Luis Potosí, produce more gradual and sustained changes, with incremental adjustments to lending conditions that align with the prolonged nature of the risk.

The findings underscore the role of synthetic control and placebo analysis in isolating the direct effects of these events, confirming the robustness of observed shifts in lending dynamics. The divergence in institutional responses to acute versus chronic climate risks highlights the adaptability of financial systems while also exposing the socioeconomic vulnerabilities exacerbated by restrictive lending practices, particularly for low-income households in hurricane-affected regions.

Ultimately, this research underscores the critical link between climate risks and financial stability. It calls for a balanced approach in risk management that considers institutional sustainability alongside the broader socioeconomic consequences of restricted credit access. Future research should explore long-term temporal dynamics, borrower behavior in response to climate shocks, and the role of policy interventions in mitigating financial inequalities. Additionally, cross-regional analyses could provide insights into how economic characteristics influence the impacts of climate events on lending conditions, offering a global perspective on the intersection of climate risks and financial stability.

A Weights

Table A: Weights of states for each variable: Hurricane Alex

States	**Loan Amount**	**LTV**	**DTI**	**Origination Fees**	**Loan Term**
Nayarit	0.057	0.082	0.064	0.070	0.083
Zacatecas	0.097	0.065	0.081	0.056	0.082
Hidalgo	0.032	0.046	0.017	0.077	0.066
Baja California Sur	0.077	0.024	0.034	0.006	0.065
Coahuila*	0.098	0.067	0.028	0.060	0.060
Durango	0.017	0.058	0.057	0.062	0.055
Ciudad de México	0.031	0.028	0.029	0.015	0.054
Veracruz	0.054	0.044	0.031	0.006	0.053
Guanajuato	0.056	0.048	0.039	0.042	0.054
Tabasco	0.012	0.018	0.024	0.006	0.053
Tlaxcala	0.099	0.031	0.048	0.012	0.052
Morelos	0.083	0.112	0.089	0.107	0.044
Colima	0.050	0.051	0.040	0.055	0.043
Querétaro	0.029	0.020	0.047	0.006	0.041
Quintana Roo	0.022	0.036	0.070	0.054	0.037
Campeche	0.009	0.051	0.056	0.063	0.037
Michoacan	0.041	0.051	0.053	0.076	0.032
Estado de México	0.002	0.021	0.047	0.065	0.023
San Luis Potosí	0.001	0.004	0.002	0.009	0.017
Jalisco	0.001	0.000	0.002	0.006	0.017
Chihuahua	0.036	0.006	0.019	0.019	0.011
Nuevo Leon*	0.019	0.007	0.002	0.007	0.010
Guerrero	0.007	0.012	0.056	0.035	0.009
Baja California	0.010	0.022	0.023	0.010	0.009
Sonora	0.004	0.006	0.002	0.008	0.007
Aguascalientes	0.001	0.001	0.039	0.005	0.006
Oaxaca	0.033	0.069	0.001	0.050	0.002
Tamaulipas*	0.001	0.001	0.015	0.005	0.002
Puebla	0.017	0.010	0.001	0.007	0.002
Sinaloa	0.014	0.015	0.001	0.007	0.002
Treated municipalities	0.004	0.007	0.001	0.007	0.001
Yucatán	0.001	0.000	0.001	0.006	0.001

The states with * represent the municipalities not affected by the event in that state.

Table B: Weights of states for each variable: San Luis Potosí Drought

State	**Loan Amount**	**LTV**	**DTI**	**Origination Fees**	**Interest Rate**	**Loan Term**
Baja California Sur	0.094	0.055	0.040	0.018	0.016	0.008
Nayarit	0.087	0.053	0.042	0.071	0.056	0.025
Colima	0.075	0.046	0.072	0.084	0.081	0.075
Tabasco	0.065	0.076	0.086	0.071	0.060	0.067
San Luis Potosí*	0.064	0.071	0.058	0.054	0.065	0.058
Campeche	0.057	0.047	0.035	0.034	0.071	0.026
Hidalgo	0.055	0.027	0.005	0.069	0.059	0.042
Oaxaca	0.054	0.011	0.027	0.025	0.028	0.003
Tlaxcala	0.048	0.063	0.029	0.058	0.081	0.068
Jalisco	0.047	0.037	0.024	0.011	0.003	0.022
Durango	0.047	0.032	0.042	0.002	0.005	0.029
Quintana Roo	0.042	0.021	0.004	0.045	0.020	0.061
Michoacan	0.035	0.090	0.078	0.044	0.039	0.088
Ciudad de México	0.034	0.035	0.032	0.013	0.007	0.014
Veracruz	0.028	0.004	0.128	0.078	0.082	0.078
Estado de México	0.026	0.030	0.011	0.033	0.020	0.033
Sinaloa	0.026	0.032	0.055	0.027	0.040	0.057
Aguascalientes	0.026	0.062	0.053	0.044	0.053	0.048
Chihuahua	0.022	0.033	0.079	0.061	0.031	0.040
Morelos	0.020	0.035	0.036	0.006	0.005	0.017
San Luis Potosí	0.018	0.043	0.003	0.039	0.005	0.005
Guerrero	0.015	0.031	0.042	0.033	0.043	0.045
Yucatánn	0.013	0.010	0.004	0.042	0.043	0.048
Tamaulipas	0.011	0.005	0.004	0.003	0.014	0.003
Zacatecas	0.008	0.031	0.003	0.029	0.032	0.019
Nuevo Leon	0.004	0.028	0.009	0.020	0.021	0.030
Guanajuato	0.003	0.012	0.003	0.003	0.004	0.004
Baja California	0.002	0.002	0.003	0.003	0.005	0.003
Chiapas	0.002	0.002	0.016	0.002	0.027	0.006
Puebla	0.002	0.002	0.002	0.002	0.004	0.003
Sonora	0.001	0.002	0.003	0.002	0.004	0.003
Querétaro	0.001	0.002	0.003	0.002	0.004	0.003
Coahuila	0.001	0.002	0.003	0.002	0.004	0.002

The states with * represent the municipalities not affected by the event in that state.

Table C: Weights of states for each variable: Hurricane Otis

States	**Loan Amount**	**LTV**	**DTI**	**Origination Fees**	**Loan Term**
Nuevo Leon	0.088	0.087	0.084	0.092	0.067
Quintana Roo	0.087	0.050	0.062	0.090	0.012
Michoacan	0.087	0.087	0.077	0.006	0.120
Guanajuato	0.085	0.062	0.064	0.033	0.019
Campeche	0.079	0.087	0.102	0.074	0.112
Tabasco	0.066	0.033	0.022	0.064	0.034
Zacatecas	0.065	0.080	0.071	0.079	0.033
Baja California	0.050	0.053	0.053	0.006	0.093
Tlaxcala	0.049	0.014	0.034	0.008	0.033
Oaxaca	0.046	0.013	0.005	0.047	0.012
San Luis Potosí	0.039	0.032	0.045	0.032	0.003
Durango	0.039	0.018	0.021	0.047	0.027
Veracruz	0.036	0.038	0.055	0.019	0.030
Jalisco	0.031	0.018	0.006	0.034	0.023
Nayarit	0.027	0.071	0.032	0.064	0.003
Aguascalientes	0.024	0.051	0.060	0.048	0.115
Chiapas	0.020	0.015	0.015	0.033	0.015
Baja California Sur	0.019	0.051	0.019	0.071	0.019
Morelos	0.013	0.018	0.026	0.024	0.010
Estado de México	0.013	0.039	0.029	0.010	0.033
Colima	0.012	0.013	0.010	0.021	0.056
Sinaloa	0.012	0.020	0.028	0.006	0.002
Sonora	0.008	0.009	0.004	0.006	0.005
Ciudad de México	0.008	0.004	0.025	0.006	0.005
Guerrero*	0.006	0.010	0.035	0.004	0.050
Querétaro	0.005	0.002	0.002	0.070	0.002
Yucatán	0.004	0.030	0.026	0.006	0.019
Coahuila	0.002	0.020	0.002	0.005	0.038
Hidalgo	0.002	0.001	0.002	0.006	0.003
Tamaulipas	0.002	0.001	0.002	0.005	0.003
Tratado	0.002	0.001	0.011	0.005	0.033
Chihuahua	0.001	0.002	0.002	0.006	0.002
Puebla	0.001	0.001	0.001	0.005	0.002

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