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August 6, 2025

Dear Organizers of the PhD Student Workshop on Climate Finance,

I am writing to express my interest in participating in the upcoming *PhD Student Workshop on Climate Finance* to be held on October 9, 2025, in Cambridge, MA. I am a PhD candidate in Economics at the University of California, Davis. My research focuses on the macroeconomic and financial consequences of climate-related shocks, with particular emphasis on natural disasters and their interaction with credit markets and insurance systems.

My current work explores how extreme events—driven by climate change—affect aggregate economic outcomes, firm-level decisions, and financial vulnerabilities. As part of my dissertation, I am currently conducting fieldwork and working as an intern at the Central Bank of Chile, where I use administrative firm-level data to investigate the muted investment response following natural disasters and the role of borrowing constraints. This project highlights the importance of the credit channel and how firm heterogeneity shapes recovery dynamics. A central question is whether improved credit access can enhance post-disaster recovery and reduce long-term economic scarring. This part of the project is currently under development, and I include additional details in the attached working paper.

In a related project with my coauthors, we examine how climate change exacerbates the challenge of insuring catastrophic natural hazards. Building on insights from the literature on tail risks (e.g., Conte & Kelly, 2018), we aim to quantify how climate-induced ambiguity influences volatility in property insurance markets. Despite its growing relevance—particularly in light of recent stresses in insurance markets across several U.S. states—this dimension remains underexplored.

Broadly, my research agenda aims to improve our understanding of how climate risk propagates through the macroeconomy and financial systems, and how policy can help mitigate its impacts. I expect to complete my PhD in the first half of 2027. Professors Frances Moore (fmoore@ucdavis.edu) and Oscar Jordá (ojorda@ucdavis.edu) are my advisors and would be happy to serve as references.

Thank you for considering my application. I would be honored to participate in the workshop and engage with fellow researchers working at the intersection of climate and finance.

Sincerely,

Matias Solorza

Matías Solorza

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United States of America

Fields of Interest: Macroeconomics, Finance, Climate Change

Affiliation

PhD Candidate in Economics at UC Davis, 2025 - present
PhD Student in Economics at UC Davis, 2022 - 2025

Education

Universidad de Chile, Master's in Applied Economics *(distinction)*, 2016.

Universidad de Chile, Professional Degree in Industrial Engineering (*highest distinction*), 2016.

Past Work Experience

Central Bank of Chile, Medium-Term Forecasting Department

- Senior Economic Analyst, October 2021 – August 2022
- Economic Analyst, September 2019 – September 2021

Banchile Inversiones, Research Department

- Economic Analyst, *Research Department,* 2017-2019.

Papers

- "The Credit Channel Through the Lens of a Semi- Structural Model " [Link to paper] Latin American Journal of Central Banking. Volume 3, Issue 2, 2022.

Policy Contributions and Notes*

- "Impacts of Macroeconomic Policies during the Covid-19 crisis". (In Spanish). Monetary Policy Report September 2021, Central Bank of Chile. [Link to paper]
- "Estimation of Structural Parameters for the Chilean Economy." (In Spanish). Monetary Policy Report June 2021, Central Bank of Chile. [Link to paper]
- "Use of Macroeconomic Models in the Central Bank of Chile." (In Spanish). December 2020, Central Bank of Chile. [Link to paper]

(*) As part of a joint effort with many other colleagues at the Central Bank of Chile

Teaching Assistant Experience

- Macroeconomic Modelling for Emerging Economies, Econ Masters/Ph. D course. U. of Chile 2021.
- Introduction to Economics, Macroeconomics, and Industrial Organization, between 2014 and 2016. *Universidad de Chile*

Seminars and Conference Presentations

- Internal seminars at the Central Bank of Chile (2024), UC Davis Economics Department (2025), and the NatuRE Policy Lab (2025). 31st International Conference on Computing in Economics and Finance (2025).
- CEMLA-FRBNY-ECB Conference on Economic and Monetary Policy in Advanced and Emerging Market Economies in the times of COVID-19. Online (presented by coauthor) (2021).
- Annual Meeting of the Chilean Economic Society. Chile (2016).

Grants, Awards and Honors

Ph.D Fellowship, Central Bank of Chile, 2022.
Funding for master's thesis. Conicyt (National Corporation of Research, Science and Technology, Chile). 2015.
Scholarship for master's program. Center for Applied Economics (CEA), University of Chile. 2015.
Outstanding Student Award, University of Chile. 2013-2014.

Computational Skills: Matlab, R, Julia, Stata, Eviews, Latex, Bloomberg.

Languages: English (fluent), Spanish (native). **Nationality**: Chilean.

Last edition: June 2025

Economic Impacts of Extreme Weather Shocks in a Developing Economy*

Matias Solorza†

Lissette Briones‡

August 2025

Abstract

We study the aggregate and disaggregated macroeconomic responses of Chilean regions to extreme weather-related shocks—such as floods and wildfires—using local projections. Our findings reveal a dynamic that contrasts with results from similar studies at the county level in the United States: these shocks lead to a persistent decline in regional GDP and a temporary reduction in private consumption. From a macroeconomic perspective, this pattern is consistent with the decapitalization of regional economies following a disaster. By leveraging a wide range of economic variables, this paper sheds light on how local economies in emerging markets adjust to natural disasters and underscores the importance of reconstruction and mitigation policies in preventing long-term economic scarring.

Keywords— natural disasters, climate economics, capital destruction, post-shock recovery

JEL Classification: E2, E32, Q54, Q58

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1 Introduction

A significant amount of research has been dedicated to the increase in global temperature, but another important aspect of climate change is the rise in natural disasters. This phenomenon has implications for both society and the macroeconomy. The relevance of this study lies in the fact that natural disasters have been increasing worldwide, and both the intensity and frequency of these events are expected to continue rising (IPCC, 2021; USGCRP, 2017). To design effective adaptation and mitigation policies, it is crucial to understand economic impacts and adjustment mechanisms in the short and medium term. This issue is particularly important because climate change will not only amplify existing risks but also introduce significant uncertainty regarding its future effects.

Most studies on the topic have focused on developed countries, particularly the United States. However, the effects in developing economies could be markedly different due to varying economic structures, adaptive capacities and insurance coverage. Hence, it is crucial to understand these differences in order to design effective adaptation and mitigation policies that are tailored to the specific needs of each country.

From current studies key questions remain: What is the economic impact of extreme weather-related shocks in developing economies? How do economies adapt after such natural disasters? Which macroeconomic shock prevails in these events? capital destruction or productivity decline?

The main objective of this study will be to measure the impact of extreme weather-related shocks and understand the adjustment mechanisms in an emerging economy. Specifically, we focus on Chile.

Our methodology is based on the approach of Roth Tran and Wilson (2024) using local projections to estimate the impacts of climate extremes. We use regional and municipal GDP, along with labor market data, to more accurately identify adjustment mechanisms at the local level. We take advantage of the wealth of regional Chilean data available on economic activity. This approach provides key information on the mechanisms of adaptation

and the type of shock that prevails in the economy after extreme weather events.

In summary, this study examines the economic impact of extreme weather-related shocks in Chile. Unlike findings observed in the U.S., we find a persistent decrease in regional GDP, a temporary decline in private consumption, and an increase in employment in two phases. At the sectoral level, the decline in GDP is mainly driven by the services and commerce sectors, while employment increases immediately in construction and with a delay in commerce. These findings are consistent with an economy that experienced a temporary productivity decline and capital destruction, according to the perspective of a Real Business Cycle (RBC) model.

The rest of the article is organized as follows: In the next section, we discuss key findings from previous research. Section III describes the data used in this study. We present our methodology in Section IV. In Section V, we present the base results. Section VI offers a case study based on these results, while Section VII presents robustness checks. Finally, Section VIII concludes the article and proposes new lines of research stemming from this study.

2 Literature Review

The literature examining the long-term economic impacts of disasters reveals a noticeable lack of consensus, underscored by a variety of empirical findings that highlight the complexity of these effects. Researchers have identified multiple potential long-term trajectories following disasters, which can manifest as economic outcomes that are below, at, or above pre-disaster trends. This diversity of results complicates the ability to draw definitive conclusions about the economic repercussions of disasters, suggesting that the context and nature of each event play critical roles in shaping outcomes.

Key studies contribute substantially to this ongoing debate. For instance, Hsiang and Jina (2014) using a panel of countries present a compelling case, arguing that cyclones typically inflict long-lasting declines in national GDP per capita. This statement is supported

by a wealth of data indicating that such disasters disrupt economic activity in the affected regions, leading to protracted recovery periods. However, contrasting studies challenge this perspective, particularly those focusing on high-income countries. These studies suggest that the economic effects of disasters can be less severe or even positive, particularly when considering factors such as robust infrastructure and effective emergency response mechanisms.

In the context of the United States, the findings become even more nuanced. Research by Deryugina (2017), Jerch et al. (2023), and Kim and Chung (2024) consistently identifies negative long-term effects of disasters on economic indicators, reinforcing the idea that the economic aftermath of events like hurricanes can result in sustained declines in GDP per capita and other key metrics. However, a different narrative emerges from studies like those by Deryugina et al. (2018) and Groen et al. (2020), which examine the aftermath of Hurricane Katrina and Hurricane Rita. These researchers argue that, in certain cases, the long-term economic impacts can be positive, driven by factors such as increased federal investment in infrastructure and a surge in population in the affected areas. Roth Tran and Wilson (2024) further contribute to this debate, they find that natural disasters triggering federal aid lead to long-term increases in income, wages, and home prices, primarily driven by hurricanes and tornadoes, with no significant impact on employment or population. The income boost is correlated with higher damages, highlighting the role of insurance and government aid, while broader regional effects are minimal.

Regarding developing economies, there's very scarce studies on the economic impact of climate extremes and channels of impact. Contrary to the U.S., literature finds that local governments often focus on disaster recovery rather than building adaptive capacity (Mirza 2003; Hay and Mimura 2010). This results could imply a negative GDP impact for emerging economies.

Last, in the case of Chile, literature has been focus so far on the impacts of slow growing effects of climate change throughout recent decades, but there is few or none on the economic impacts of climate extremes. These studies so far shows that rising temperatures and

decreasing precipitation have adversely affected key economic sectors, and find that extreme temperatures and droughts exacerbate the effects of climate change (Hernández and Madeira 2021; Reszczynski 2024). The Central Bank of Chile (Central Bank of Chile, 2024) also conducts a survey on climate change effects on firms and finds that around 50% of companies in 2024 declared to have been affected by extreme weather events in the last 5 years, 22% reported a decrease in production and 13% a loss of capital. Additionally, Marulanda et al. (2022) finds that the country has a significant financial risk due to the substantial resources required to address extreme disasters, emphasizing potential considerable impacts for the national economy.

From these varied findings, several key takeaways emerge. First, many studies tend to focus on single disaster types, which may limit the generalization of their conclusions across different contexts. This single-focus approach risks overlook the broader implications of how various disasters affect economic trajectories. In addition, cross-country analyses often fail to adequately account for local dynamics, particularly in the United States and developing countries like Chile, where the availability and efficacy of disaster aid can vary dramatically. This disparity in aid responses can lead to significantly different economic outcomes in similar disaster scenarios. Finally, considerable gap remains in our understanding of the underlying mechanisms that contribute to heterogeneity and spatial dynamics after a disaster. More comprehensive research is needed to explore these complexities, as they are crucial to formulate effective policies and interventions aimed at mitigating the long-term economic consequences of climate extremes.

3 Data

This study leverages a robust dataset to investigate the regional economic impacts of extreme weather events in Chile. The economic variables of interest include quarterly data on regional Gross Domestic Product (GDP), household consumption, investment and labor

market outcomes such as employment, real wages and hours, spanning from 2013 to 2024. These indicators provide a temporal dimension that allows for the examination of economic trends over time. In addition, the analysis integrates monthly electronic invoice data from Chile, covering the period from 2017 to 2024. This dataset comprises a total of 1,440 observations, with data aggregated by region, facilitating a detailed understanding of intermediate consumption patterns.

The electronic invoice data is particularly noteworthy as it includes firm-level information from sales in between firms, accounting for 31,486 observations, which enables an assessment of business activities across different municipalities. Moreover, this data is a subset of the information used by National Accounts in the Central Bank to calculate GDP. This granular approach allows for the disaggregation of economic impacts at the local level. Moreover, employment data is available on a monthly basis from 2013 to 2024, allowing for a thorough examination of labor market responses to economic conditions and external shocks.

In conjunction with these economic variables, the study incorporates natural disaster[*] data sourced from the Emergency Events Database (EMDAT)[†], managed by the Centre for Research on the Epidemiology of Disasters (CRED) at the Université Catholique de Louvain. This dataset captures various natural disaster shocks, enabling the analysis of their frequency, intensity, and regional distribution. By combining these economic and disaster data, the research aims to elucidate the complex interactions between regional economic performance and the impacts of natural disasters, providing valuable insights into resilience and recovery strategies in the Chilean context.

Figure 1 presents a comprehensive visualization of the population of Chile, broken down by regions, along with an analysis of economic activity in each area. In general, a positive correlation is observed between population and economic activity, suggesting that regions with higher population density tend to exhibit higher levels of economic activity. However,

[*]The inclusion criteria for an event to be considered a disaster includes: At least ten deaths (including dead and missing), at least 100 affected (people affected, injured, or homeless) and a call for international assistance or an emergency declaration.

[†]EM-DAT, CRED / UCLouvain, Brussels, Belgium – www.emdat.be

this general trend shows a notable exception in the northern part of the country, where the economy is heavily influenced by mining. This economic sectorization leads to disproportionately high economic activity despite a relatively low population compared to other regions, highlighting the significance of extractive activities in shaping the regional economic landscape.

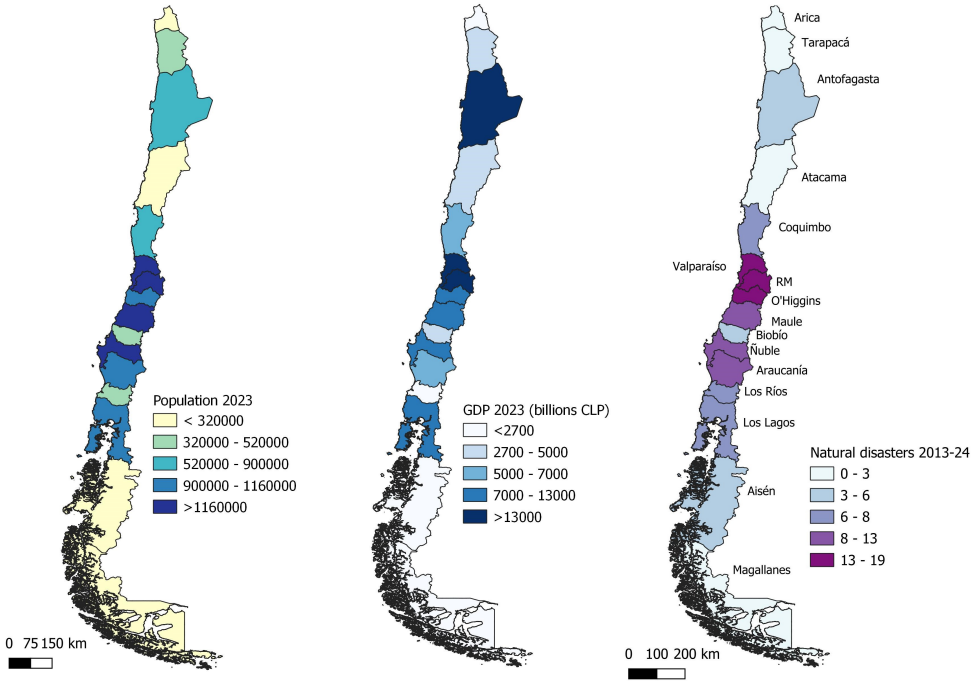
Additionally, the figure includes an analysis of the frequency of natural disasters by region, adding a crucial dimension to the understanding of the risks faced by these areas. Regions with high mining activity, particularly in the north, not only experience significant economic dynamism but are also exposed to certain types of natural disasters, such as earthquakes and landslides, which can have devastating impacts on both the population and the economy. The combination of high economic activity and vulnerability to natural disasters underscores the need to implement risk management strategies that take these regional particularities into account.

Thus, Figure 1 not only illustrates the distribution of the population and its economic activity but also highlights the complex interrelationship between these factors and exposure to extreme climate events. This information is vital for formulating public policies aimed at promoting sustainable and resilient economic development across all regions of Chile, especially in those facing unique challenges due to their predominant economic activities and geography. Ultimately, understanding natural disasters is important because they occur in densely populated areas.

The extreme climate events analyzed in the study are categorized into two main types for analysis purposes: wildfires and floods. Floods will contain three types of events: floods, storms and mass movements (wet). All three disasters are related to meteorological or hydrological phenomenons of heavy and torrential rains, and some produced in addition slides of land, mud, snow or rock. In the case of wildfires, they are described as part of the climatological subgroup by EMDAT and some are described associated to heat waves, high temperatures and strong winds. A total of 143 disasters are considered, of which two-thirds

are floods and the remaining third are wildfires.

Figure 1: Population, Activity and Natural Disasters



Note: Own elaboration with data from EM-DAT, CRED / UCLouvain, Brussels, Belgium – www.emdat.be, Central Bank of Chile, and the National Institute of Statistics (INE).

4 Methodology

We estimate the dynamic causal effects to extreme weather event shocks using local projections à la Jordà (2005) modified for panel data. In our baseline specification, we estimate the following equation for a series of horizons $h \geq 0$:

$$y_{c,t+h} - y_{c,t-1} = \alpha_t^h + \gamma_c^h + \theta^h D_{c,t}^{shock} + x_t'\beta + \epsilon_{t+h} \tag{1}$$

$y_{c,t}$ is an economic outcome of interest in region c in period t, measured in logs. The economic variable of interest will be activity, measured in GDP (Gross Domestic Product) and also in firm sales. Additionally, labor data will be considered, such as the number of employed individuals, unemployed individuals, and the labor force. $D_{c,t}^{shock}$ is the key treatment variable, equaling one if the region experienced a disaster in period t and zero otherwise. x_t is a vector of controls: 4 lags of previous growth rates for quarterly data and 12 lags for monthly data. α_c^h and γ_t^h represent monthly and region fixed effects. Our specification in equation 1 is the same as that used by Roth Tran and Wilson (2024).

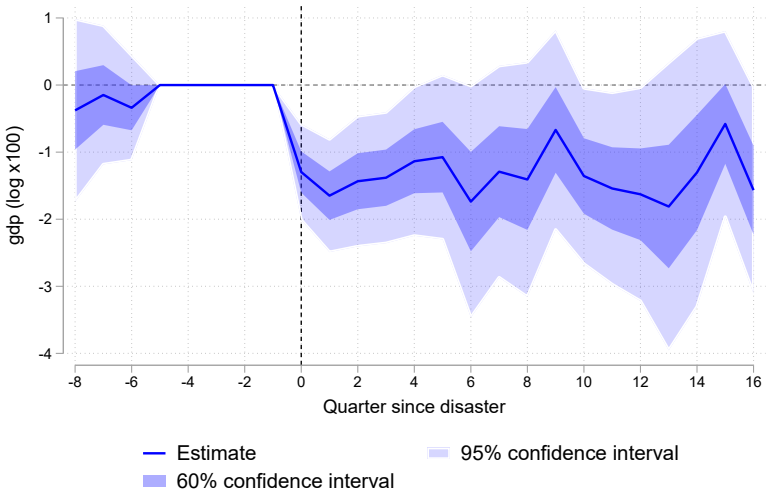
In this specification the variable of interest will be the long difference $(y_{c,t+h} - y_{c,t-1})$, which is interpreted as the cumulative regional effect from receiving the shock in each period in regard to time zero with respect to not affected regions. We refer to the dynamic cumulative causal effects up to horizon h as the Impulse Response Function (IRF).

5 Results

Figure 2 shows the results for GDP from the estimation of equation 1 using regional-gdp data. The point estimate results indicate that, immediately, regional GDP falls by about 1.5%, and this decline is significantly different from zero. Furthermore, the results remain significantly different from zero for four quarters thereafter. However, it is important to note that the decline in activity is persistent in terms of its level, a.k.a. in the horizon never

crosses zero or experiences a notable recovery.

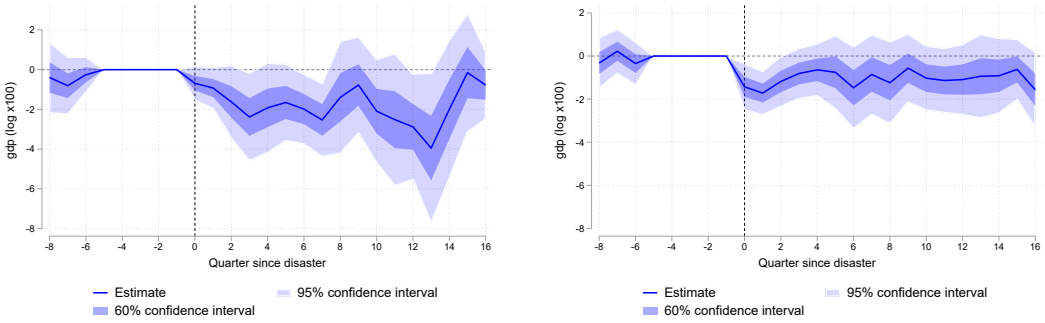
Figure 2: Impulse Response of Regional GDP to Natural Disaster Shock



Note: Standard errors are clustered at the regional level.

Figure 2 shows the results for all natural disasters. It is important to highlight the differences between the two types of disasters included in our sample: wildfires and floods. Figure 3 displays the results categorized by type of natural disaster.

Figure 3: Impulse Response of selected Regional GDP to Natural Disaster Shock



(a) Wildfire (b) Flood

Note: Standard errors are clustered at the regional level.

Figure 3 shows that the response to wildfires is more uncertain, in contrast to what typ-

ically occurs after a flood. Wildfires shows an increasing response across quarters, although less statistically significant and with higher dispersion in confidence intervals. Additionally, shows a recovery at the end of the horizon. In contrast, floods experience a higher immediate effect at $t = 0$ and does not show a recovery in the end of the period. Hence. the latter is the main driver of the total average result since it covers two thirds of the studied events.

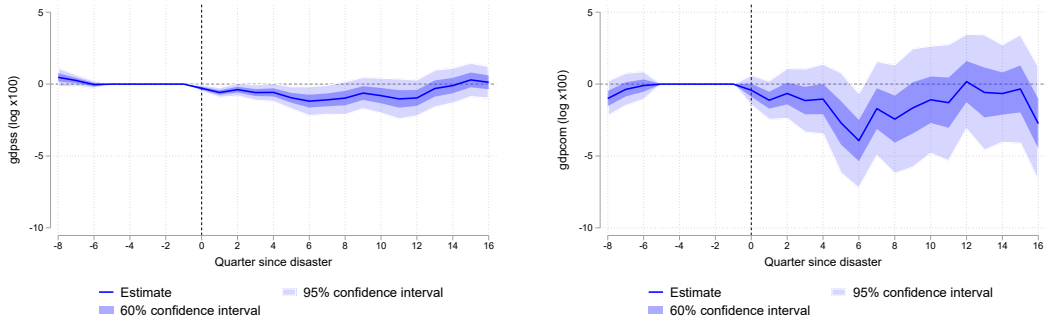
5.1 GDP by sector

The next step is to analyze the dynamics of regional activity from the perspective of supply and sectors. Figure 4 presents the results for selected sectors. Only those sectors that show statistically significant results will be included.

We observe that initial drop is linked to the services sectors, which compared to commerce has a low impact, but given the incidence in overall economy (67.8%) is relevant and statistically significant. Due to the level of data aggregation at the regional level, which limits further breakdown, the services sector encompasses many activities[‡]. Some of these, such as transport, personal services which includes education, and touristic associated services, as restaurant and hotels, would be expected to be more heavily affected, while others, like financial services or public administration, may be less impacted.

[‡]GDP services include: restaurants and hotels, transport, information and communications services, financial services, business services, dwelling services and real estate, personal services, and public administration.

Figure 4: Impulse Response of selected Regional GDP sectors to Natural Disaster Shock



(a) Services(67.8%) (b) Wholesale and retail trade (9.4%)

Note: Standard errors are clustered at the regional level. Percentage in parenthesis is participation over total GDP in 2023.

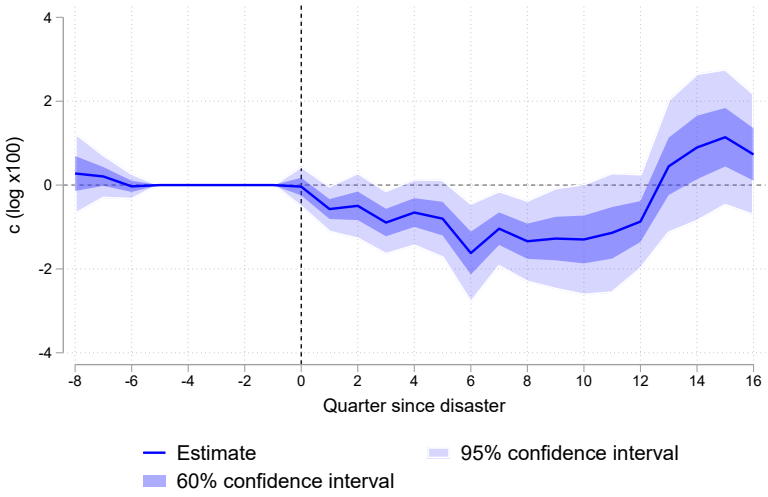
Figure 4 also highlights that the largest decline in trade occurs a year after the disaster, although, in general, the response is more moderate than the behavior of GDP shown in Figure 2, which makes sense from a theoretical standpoint.

5.2 GDP Components of Demand: Household Consumption

This section presents a breakdown of the demand side. The available regional data includes household consumption and its subcategories: non-durable goods, durable goods, and services, which represent 43.4%, 7.6%, and 49.1%, of private consumption respectively.

Figure 5 shows the effect of a natural disaster on household consumption. It underscores that the magnitudes are comparable to those of GDP, albeit with delayed outcomes. This phenomenon is consistent when considering the smoothing theory of consumption. On the other hand, and in contrast to what we observe in the supply side, there is a clear recovery and even a positive effect after 3 years. Although it is not statistically significant, it could be related to labor market behavior, which we will explore in the next section, as well as to the response of services.

Figure 5: Impulse Response of Household Consumption to Natural Disaster Shock

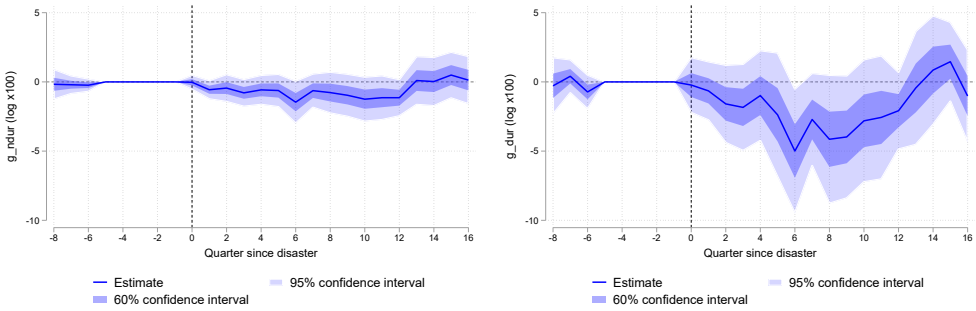


Note: Standard errors are clustered at the regional level.

Figure 6 shows the results for the consumption subcategories. As expected, the decline is more pronounced in durable goods and services, in contrast to the effect on durable goods consumption, which makes sense, as these are the types of products whose replacement can be delayed. On the other hand, we also highlight that the increase in consumption from the third year onward is mainly explained by services and durable goods, although all three components go back to the zero area.

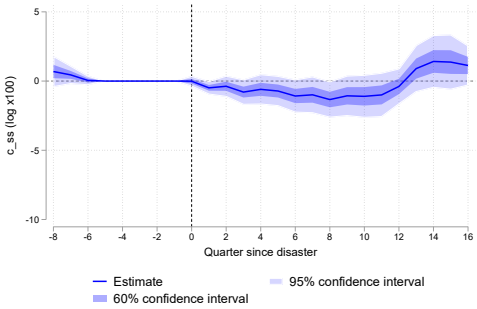
In summary, the pattern of regional consumption following a natural disaster aligns with a narrative in which durable goods are the most affected. Eventually after the disaster, there is a rebound in the consumption of durable goods, which was previously hit hard, as well as in services. One possible interpretation is that, in response to capital destruction or emergency management, non-essential consumption shifts to redirect economic resources toward more urgent priorities, such as precautionary savings or due to reduced supply.

Figure 6: Impulse Response of Household Consumption to Natural Disaster Shock



(a) Non durable goods (43.4%)

(b) Durable goods (7.6%)



(c) Services (49.1%)

Note: Standard errors are clustered at the regional level. Percentage in parenthesis is participation over total Household Consumption in 2023.

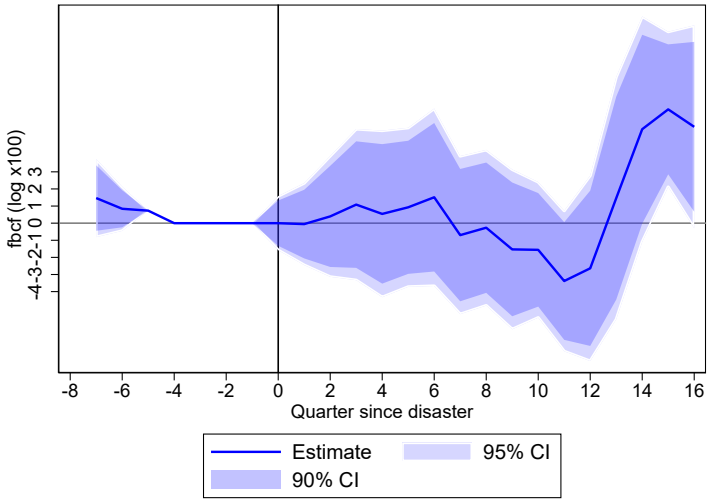
5.3 GDP Components of Demand: Investment

This section presents the results at the regional investment level. Figure 7 shows the response of regional investment to a natural disaster shock. It is important to note that the investment data correspond to investment expenditure flows by firms in Chile. These series are constructed using invoices from the Chilean Internal Revenue Service (SII) for purchases of machinery, equipment, construction, and related works, as well as customs data on imports. Firms may belong to either the public or private sector. Therefore, these data do not represent the capital stock—calculated by the National Accounts of the Central Bank of Chile (BCCh) and unavailable at the regional level—but rather the flow of new investment.

From an analytical perspective, it is relevant to highlight that, following a natural disaster shock—which can be assumed to destroy productive capital—there is no significant increase

in investment aimed at rebuilding the affected capital. However, at a three-year horizon, investment does increase, coinciding with a recovery in private consumption. Our hypothesis is that this increase in investment after three years of the disaster is primarily driven by the rebound in private consumption, rather than a direct response to the disaster itself.

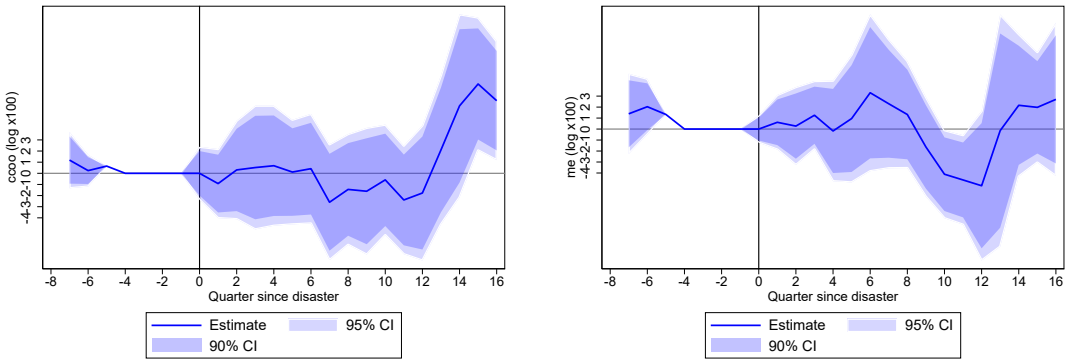
Figure 7: Impulse Response of Investment to Natural Disaster Shock



Note: Standard errors are clustered at the regional level.

To further explore the underlying dynamics, we disaggregate investment into its two main components: construction and infrastructure works, and machinery and equipment. The relative shares of these components have remained fairly stable over the past ten years, with 64.7% corresponding to construction and works, and 35.2% to machinery and equipment. Figure 8 displays the response of both components to a natural disaster shock. We find that the behavior of the construction and works component closely mirrors the aggregate investment response discussed above. In contrast, the response of the machinery and equipment component is more muted and does not show a late-horizon increase.

Figure 8: Impulse Response of components of investment to Natural Disaster Shock



(a) Construction and other investment works (64.7%)

(b) Machinery and Equipment (35.2%)

Note: Standard errors are clustered at the regional level. Percentage in parenthesis is participation over total investment in 2015-2024.

5.4 Labor Market

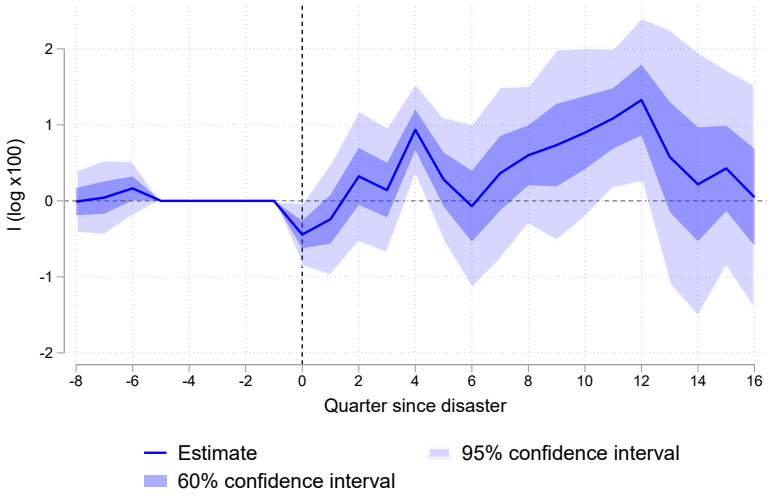
In this subsection, we will analyze the response of the labor market to a disaster. Figure 9 shows the results for employment, while Figure 10 shows the results for unemployment. Finally, Figure 11 shows the results for the labor force and inactive population.

It is important to note that the effect on employment is positive, in contrast to the negative impact on output. However, it is interesting to observe that the increase in employment occurs in two waves: the first in the first year and the second starting in the second year. This dynamic can be explained from a sectoral perspective. Figure 12 shows that the first wave is more closely related to construction activities, while the second is related to other activities. We interpret this as an initial response to the disaster, followed by longer-term investments and projects, which may be related to a re-evaluation of the disaster costs and/or to adaptation or mitigation measures that involve a more extended development process.

On the other hand, the labor market adjustment does not appear to be driven by un-

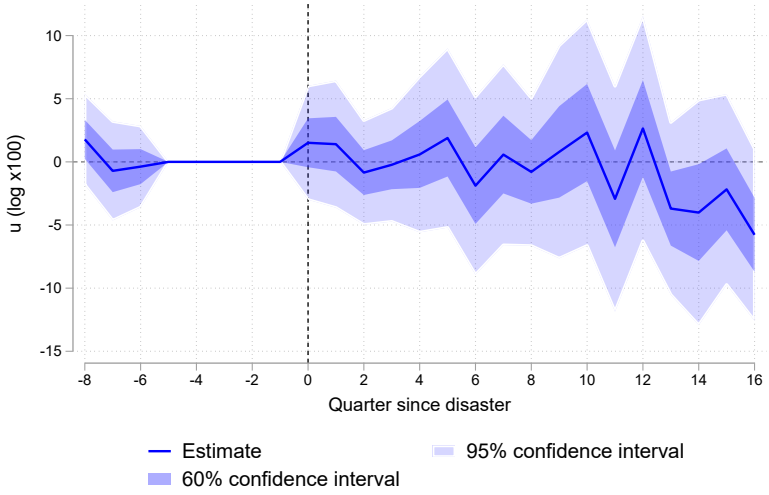
employment. However, we cannot rule out an impact on labor income since we do not have that data available.

Figure 9: Impulse Response of Regional Employment to Natural Disaster Shock



Note: Standard errors are clustered at the regional level.

Figure 10: Impulse Response of Regional Unemployment to Natural Disaster Shock

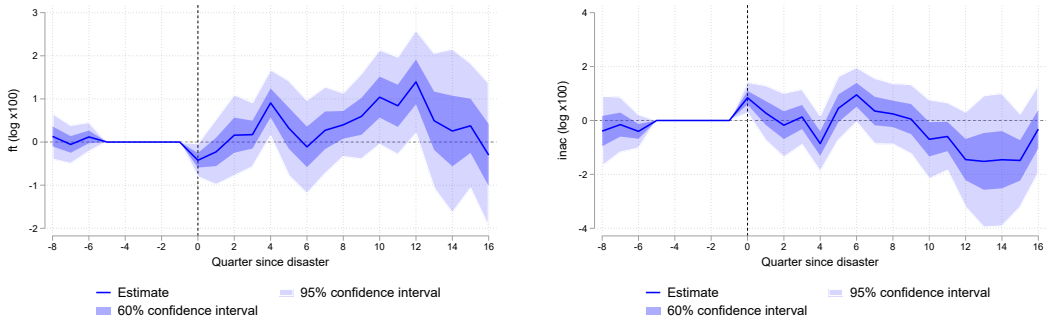


Note: Standard errors are clustered at the regional level.

Finally, figure 11 shows that the increase in employment depicted in Figure 7 is linked to changes in the labor force. Notably, the rise in the labor force coincides with a decrease in

the inactive population, i.e., individuals who are neither working nor actively seeking work. In summary, employment increases in two waves as people transition from inactivity to the labor market, into employment status.

Figure 11: Impulse Response of Labor Market to Natural Disaster Shock



(a) Labor force (b) Inactive population

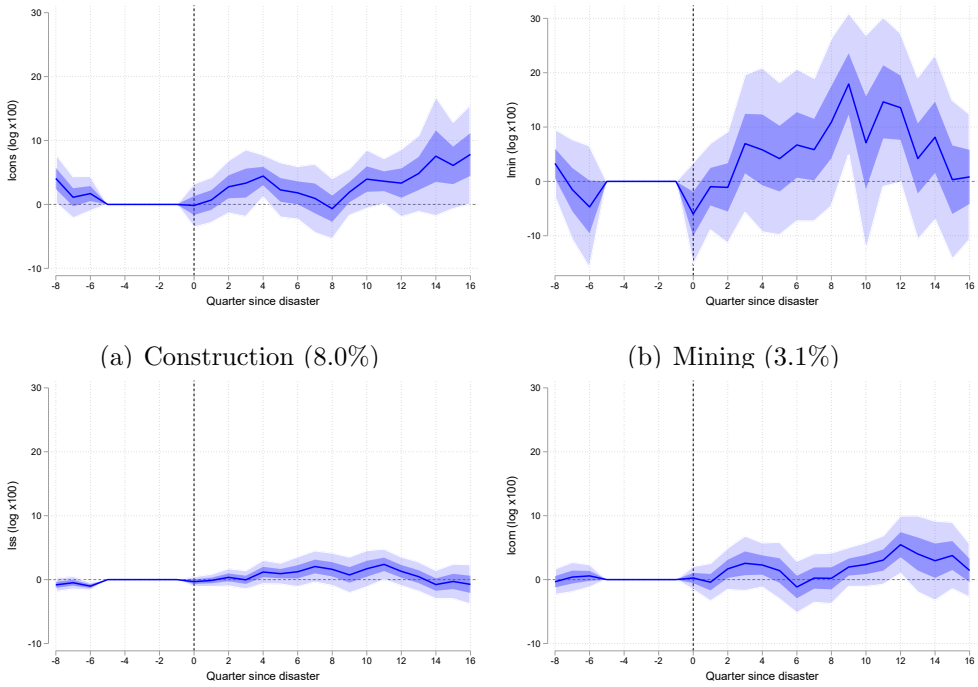
Note: Standard errors are clustered at the regional level.

Finally, we present the response of formal wages to the shock. The data are obtained from administrative microdata from the pension fund administrators (AFP)[§], and thus capture only the formal sector of the economy. In the case of Chile, this represents approximately 70% of the total workforce.

Figure 13 shows the evolution of real formal wages, deflated using the headline Consumer Price Index (CPI), over the quarters following the disaster. We observe a persistent decline in wages, with a trajectory that broadly mirrors that of GDP, albeit with a smaller magnitude. The decline reaches its lowest point around the sixth quarter, followed by a very gradual recovery that does not return to pre-shock levels within the observed time frame.

[§]This study is conducted within the scope of the research agenda developed by the Central Bank of Chile (BCCh) in economic and financial matters within its competence, under which the BCCh has access to anonymized information from various public and private entities, by virtue of collaboration agreements signed with these institutions. To ensure the privacy of workers and companies, the BCCh requires that the development, extraction, and publication of the results must not allow the direct or indirect identification of natural or legal persons. BCCh officials processed the disaggregated data. All analysis was conducted by the authors and does not involve or commit Superintendencia de Pensiones

Figure 12: Impulse Response of selected employment sectors to Natural Disaster Shock



(a) Construction (8.0%)

(b) Mining (3.1%)

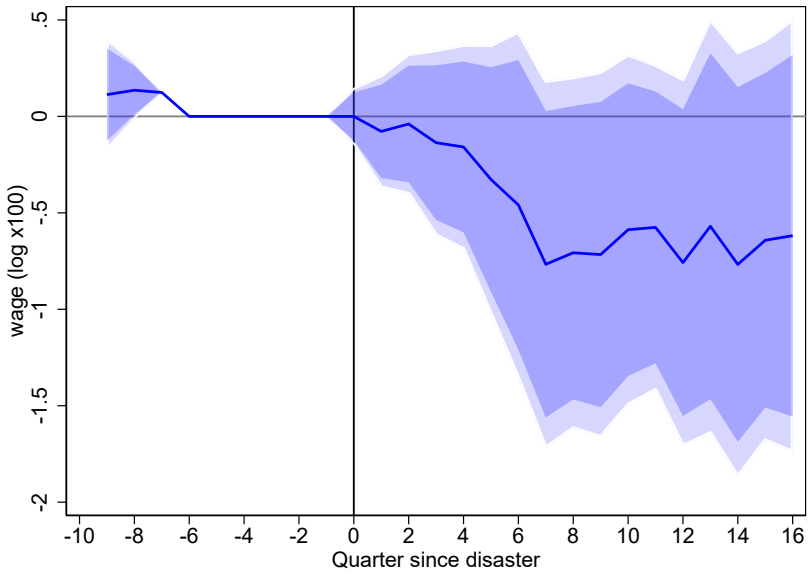
(c) Services (52.4%)

(d) Commerce (19.2%)

Note: Standard errors are clustered at the regional level. Participation of 2023 employment is in parentheses.

The 95% and 90% confidence intervals indicate that the decline is statistically significant from approximately the second quarter onward, reinforcing the evidence of a sustained negative impact on formal labor income.

Figure 13: Impulse Response of Regional Wages to Natural Disaster Shock



Note: Standard errors are clustered at the regional level.

6 Discussion

This section discusses the results as a whole, aiming to identify the broader picture and interpret the observed responses from a perspective as close as possible to general equilibrium, given the available data.

Figure 14 summarizes the main aggregate responses following a natural disaster. First, we observe a persistent decline in GDP, accompanied by a contraction in consumption, which only begins to recover around the third year. Employment exhibits a transitory increase after the shock, although the data do not clearly reveal whether this uptick is driven primarily by transitions from inactivity or from unemployment. Formal real wages —representing approximately 70% of the Chilean labor market— show a sustained decline, while hours worked display a pattern similar to that of consumption.

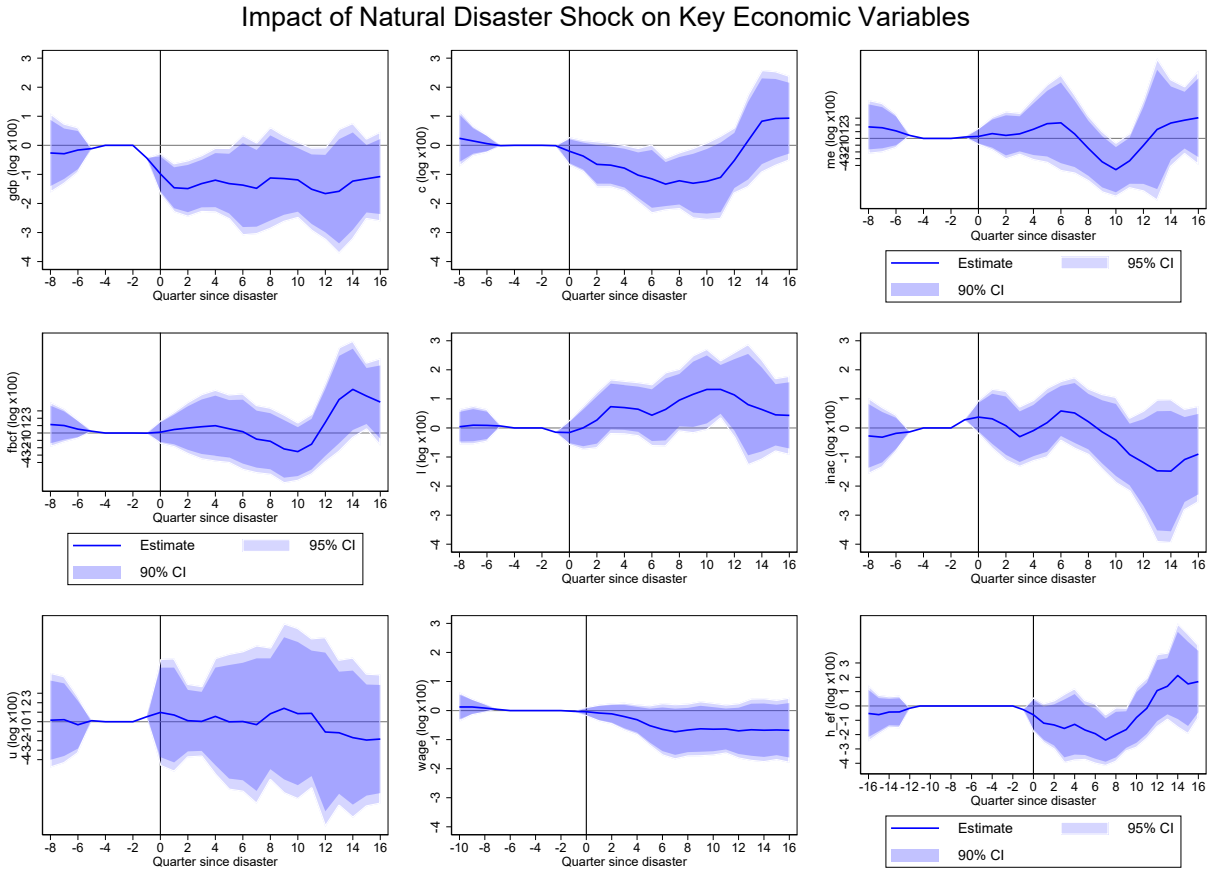
From a macroeconomic perspective, this set of responses is consistent with a regional economy that has become decapitalized in the aftermath of the disaster. This interpretation

could be further explored in future work using regional investment data.

These results point to a regional dynamic that differs from findings in similar studies conducted at the county level in the United States. In this regard, they offer a first step toward understanding how local economies in developed and emerging countries respond to natural disasters, and they highlight the importance of reconstruction and mitigation policies in preventing persistent scarring in local economic activity.

In this international comparison, identifying the role of fiscal responses and insurance mechanisms is key, as they may be critical in explaining the differences observed between advanced and emerging economies, such as the United States and Chile.

Figure 14: Impulse Response of Key Economic Variables to Natural Disaster Shock

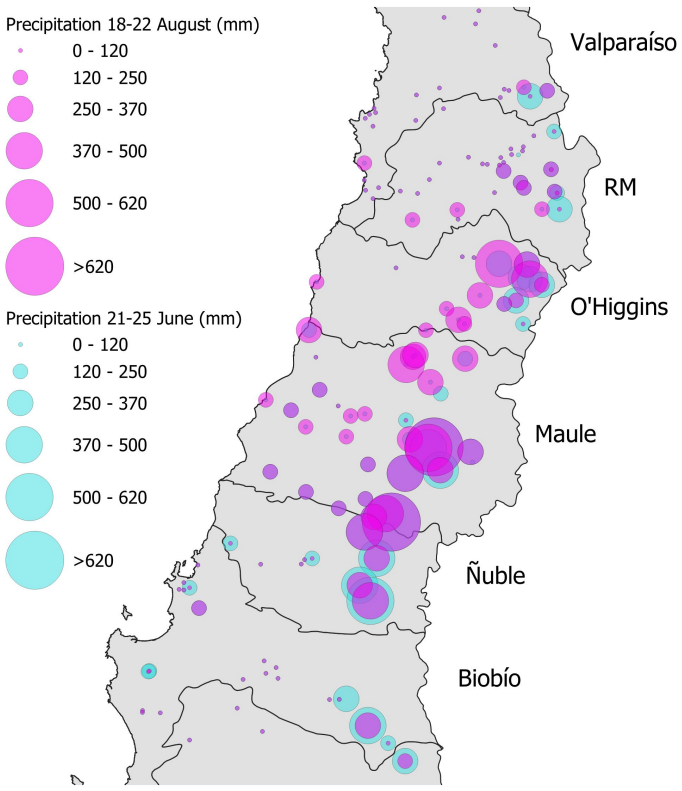


Note: See main text for the definition of the variables. Standard errors are clustered at the regional level. Smoothed IRFs.

7 Application: Floods 2023

In 2023, Chile experienced significant floods in June and August, marking the most severe floods since 2018. These disasters were particularly notable for their extensive water volume and widespread impact on the territory (Figure 15). To assess the economic consequences, we used the calculated IRF to estimate the cumulative effect of the floods by the fourth quarter of 2023. In the exercise, we consider the amount of affected regions and reconstruct levels from time zero when each shock happens using the lower interval estimated for floods, and then we calculate an average for the year to assess impact at the end of 2023. Our analysis, which takes a conservative approach given the uncertainty associated, suggests that the floods likely resulted in a reduction of at least 0.2 percentage points in the country's GDP for the year. This estimate reflects the substantial economic disruption caused by the floods, which affected both production and infrastructure across affected regions.

Figure 15: Floods in 2023



Note: Own elaboration based on data from Center for Climate and Resilience Science (CR2).

8 Robustness exercises

We perform several robustness exercises to validate the points discussed earlier. In this section, we briefly discuss them and further details and graphs are presented in the appendices.

- **Monthly company invoices:** In order to contrast the results found in regional GDP, we estimate the monthly impact of extreme weather related shocks exploiting the administrative database of company invoices, which will be a proxy for a subset of economic sectors.

- **Removing years of sample:** To test whether the estimation is affected by a set

of years, in particular the pandemic, we will test results removing the latter years (Sample: 2013-19) and also starting from 2015.

- **Removing regions of the sample:** Another question, is if a particular region's movement is driving the overall result. So we perform an exercise of excluding regions one by one and estimating the IRF. This results can be given upon request.

- **De-trended data:** Finally, we check is existing trends are relevant on the estimations results found by re-estimating the IRFs with de-trended data. We tested linear and quadratic trends. This results can be given upon request.

Overall, main conclusions sustain throughout the different exercises. Negative economic activity effect is also obtain from administrative sources, COVID-19 pandemic and no particular region seems to be driving overall results. Although, there are some interesting results from removing years initial years in the sample, versus the latter.

Although results in general remain within the confidence interval, when removing 2013-14 from the sample, GDP shows a recovery at the end of the horizon and consumption shows a deeper fall three years ahead. In addition, when removing 2020-24 employment stops showing the second positive wave. These results, are suggestive evidence of a possible adaptive behavior from economic sectors shown in employment and GDP, and a deepening of contractive effects for households, compatible with precautionary savings.

9 Conclusion

In this study, we examine the dynamic responses of Chilean regions to extreme weather events using a panel data local projections approach. We find a persistent decline in regional GDP levels, while private consumption exhibits a temporary contraction. In contrast, employment increases in two distinct waves, primarily driven by individuals transitioning from inactivity into the labor force.

At the sectoral level, the GDP decline is mainly explained by contractions in services and retail. On the employment side, we observe a short-term increase in construction employment, followed by delayed effects in the retail sectors.

Taken together, the decline in aggregate GDP alongside rising employment implies that the shock may have affected capital stocks and/or labor productivity. Supporting this interpretation, survey evidence from Central Bank of Chile (2024) indicates that firms reported capital losses due to extreme weather events, lending credibility to the hypothesis of post-disaster decapitalization.

Finally, in contrast to the positive or neutral effects documented in some developed countries, our findings point to a persistent decline in regional GDP and a temporary reduction in private consumption. From a macroeconomic perspective, this pattern is consistent with a decapitalization of regional economies following the disaster. Our findings reveal a dynamic that contrasts with results from similar studies at the county level in the United States. By leveraging a wide range of economic variables, this paper sheds light on how local economies in emerging countries adjust to natural disasters and underscores the importance of reconstruction and mitigation policies to prevent long-term economic scarring.

References

Central Bank of Chile (2024). Business perceptions report may 2024.

Deryugina, T. (2017). The fiscal cost of hurricanes: Disaster aid versus social insurance. *American Economic Journal: Economic Policy*, 9(3):168–198.

Deryugina, T., Kawano, L., and Levitt, S. (2018). The economic impact of hurricane katrina on its victims: Evidence from individual tax returns. *American Economic Journal: Applied Economics*, 10(2):202–233.

Groen, J. A., Kutzbach, M. J., and Polivka, A. E. (2020). Storms and jobs: The effect of hurricanes on individuals' employment and earnings over the long term. *Journal of Labor Economics*, 38(3):653–685.

Hay, J. and Mimura, N. (2010). The changing nature of extreme weather and climate events: risks to sustainable development. *Geomatics, Natural Hazards and Risk*, 1(1):3–18.

Hernández, K. and Madeira, C. (2021). The impact of climate change on economic output in chile: past and future. *Working paper series*, (933).

Hsiang, S. M. and Jina, A. S. (2014). The causal effect of environmental catastrophe on long-run economic growth: Evidence from 6,700 cyclones. *National Bureau of Economic Research*.

Jerch, R., Kahn, M. E., and Lin, G. C. (2023). Local public finance dynamics and hurricane shocks. *Journal of Urban Economics*, 134:103516.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American economic review*, 95(1):161–182.

Kim, N.-Y. and Chung, J.-B. (2024). Disaster resilience of korean cities using data envelopment analysis. *Natural Hazards Review*, 25(2):04024003.

Marulanda, M., de la Llera, J., and Cardona, O. (2022). A macroeconomic disaster risk analysis: The case study of chile. *International Journal of Disaster Risk Reduction*, 74:102875.

Mirza, M. Q. (2003). Climate change and extreme weather events: can developing countries adapt? *Climate Policy*, 3(3):233–248.

Reszczynski, M. (2024). Altas temperaturas y escasez de lluvia: el impacto del cambio climático en la actividad económica de chile. *Working paper series*, (1002).

Roth Tran, B. and Wilson, D. J. (2024). The local economic impact of natural disasters. *Federal Reserve Bank of San Francisco Working Paper 2020-34*.

Appendix

A GDP: Monthly company invoices

This exercise involves estimating equation 1 , but with monthly data using company billing data. Company billing serves as a monthly proxy for activity since it's a portion of the data that is compiled by National Accounts to calculate GDP.

The benefits of company billing include its availability at a monthly frequency, unlike regional GDP. However, a downside is that it relies on more recent time series, and it does not cover all of the economic sectors. For instance, it's a good proxy for Services and retail trade, but not for the mining sector or construction.

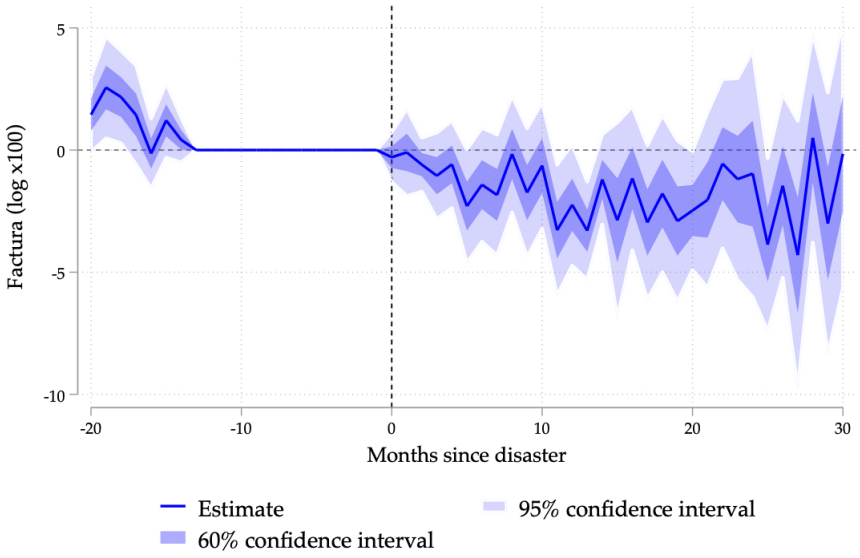
Table 1 shows the correlation between annual growth of regional GDP and the company billing.

Regions	Name	Corr(X,Y)
1	Región de Tarapacá	0.51
2	Región de Antofagasta	-0.09
3	Región de Atacama	0.71
4	Región de Coquimbo	0.57
5	Región de Valparaíso	0.89
6	Región del Libertador General Bernardo OHiggins	0.58
7	Región del Maule	0.54
8	Región del Biobío	0.48
9	Región de La Araucanía	0.54
10	Región de Los Lagos	0.54
11	Región de Aysén del General Carlos Ibáñez del Campo	0.23
12	Región de Magallanes y de la Antártica Chilena	0.91
13	Región Metropolitana de Santiago	0.96
14	Región de Los Ríos	0.77
15	Región de Arica y Parinacota	0.62
16	Región de Ñuble	0.80

Table 1: Correlation between annual variation (%) regional FE and regional GDP.

The results of the estimation are shown below.

Figure 16: Impulse Response of Company Invoices to Natural Disaster Shock



Note: Standard errors are clustered at the regional level.

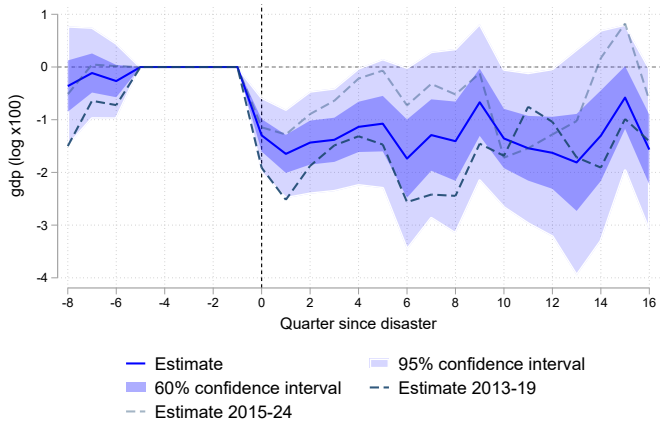
We note that overall the directions and orders of magnitude are similar to those of the regional data, although, due to the volatility of the series, the estimation is less smooth.

B Removing years of the sample

How much are our results influenced by the sample? The results differ significantly depending on whether we focus on the beginning or the end of the sample. To explore this, we will repeat the estimation of equation 1, dividing the sample into two periods of similar length: 2013-2019 and 2015-2024. This will also help to evaluate the results removing the pandemic.

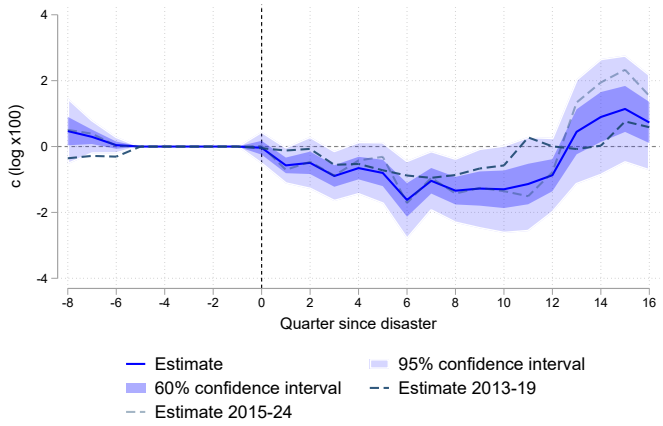
The results are shown below. There are some relevant differences as stated in the main document, however both estimates fall within the confidence interval.

Figure 17: Impulse Response of GDP to Natural Disaster Shock



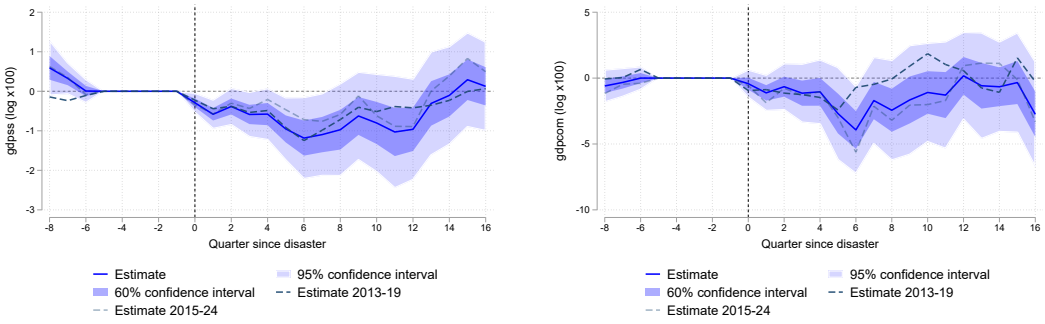
Note: Standard errors are clustered at the regional level.

Figure 18: Impulse Response of Consumption to Natural Disaster Shock



Note: Standard errors are clustered at the regional level.

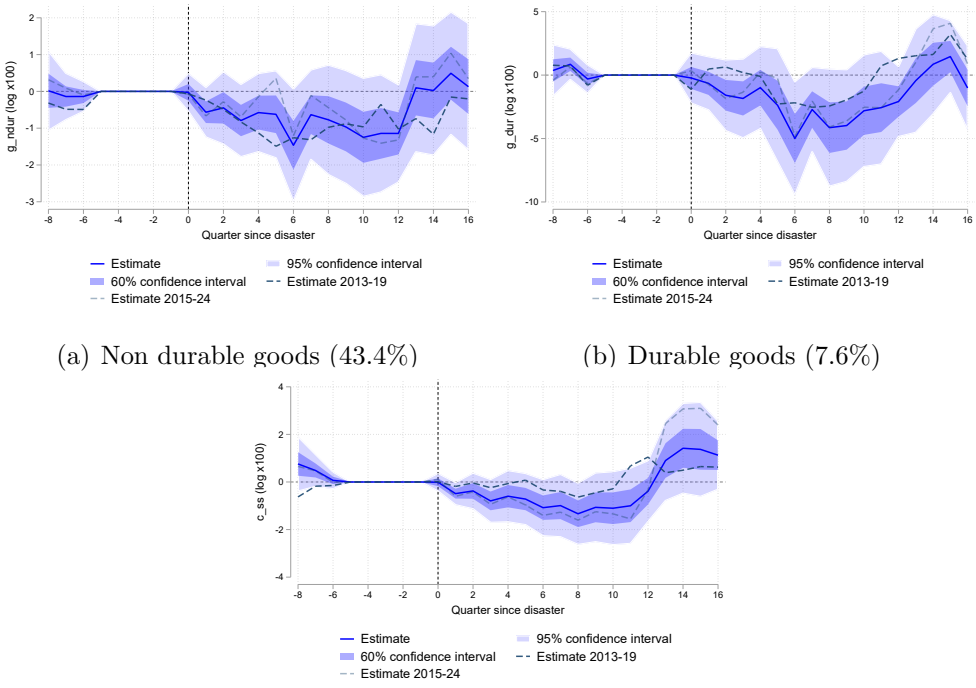
Figure 19: Impulse Response of selected Regional GDP sectors to Natural Disaster Shock



(a) Services(67.8%) (b) Commerce (9.4%)

Note: Standard errors are clustered at the regional level. Percentage in parenthesis is participation over total GDP in 2023

Figure 20: Impulse Response of Household Consumption to Natural Disaster Shock

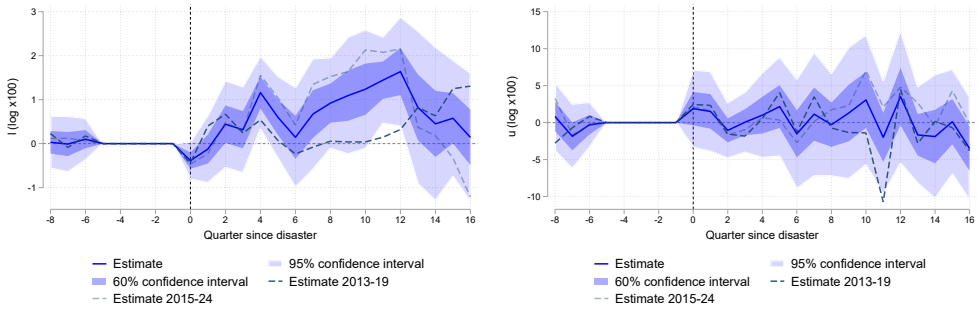


(a) Non durable goods (43.4%) (b) Durable goods (7.6%)

(c) Services (49.1%)

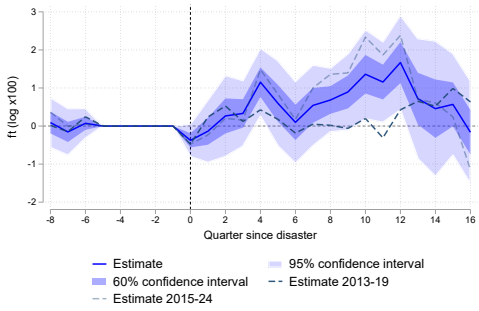
Note: Standard errors are clustered at the regional level. Percentage in parenthesis is participation over total Household Consumption in 2023.

Figure 21: Impulse Response of labor market to Natural Disaster Shock

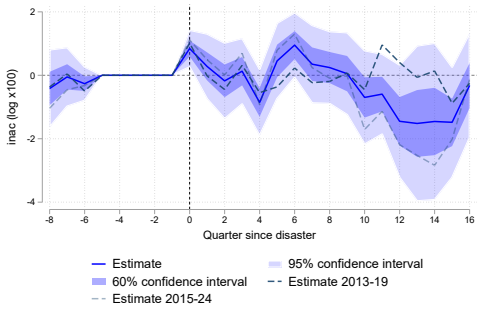


(a) Employment

(b) Unemployment



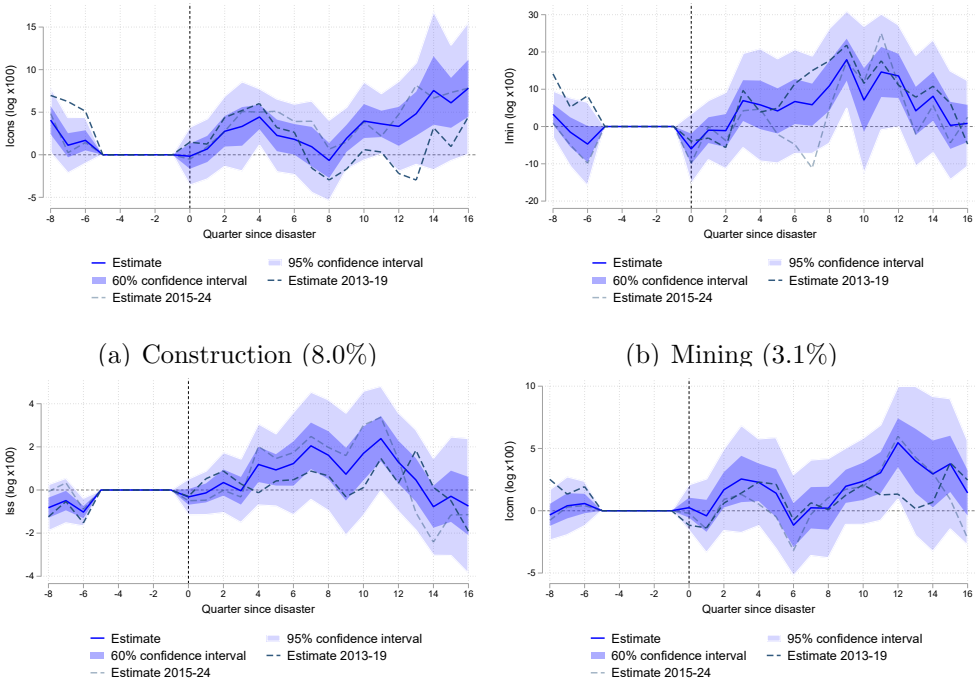
(c) Labor force



(d) Inactive population

Note: Standard errors are clustered at the regional level.

Figure 22: Impulse Response of selected employment sectors to Natural Disaster Shock



(a) Construction (8.0%)

(b) Mining (3.1%)

(c) Services (52.4%)

(d) Commerce (19.2%)

Note: Standard errors are clustered at the regional level. Participation of 2023 employment is in parentheses.