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Assessing physical risk impact of climate change: a focus on Chile[1]

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[1] This contribution was prepared for the workshop. The views expressed are those of the authors and do not necessarily reflect the views of the Central Bank of the Republic of Türkiye, the BIS, the IFC or the other central banks and institutions represented at the event.

ESTUDIOS ECONÓMICOS ESTADÍSTICOS

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Assessing Physical Risk Impact of Climate Change: A Focus on Chile[1]

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Resumen

El cambio climático plantea desafíos importantes para las economías de todo el mundo, incluido Chile, donde los efectos adversos ya son evidentes y se espera que empeoren. Para evaluar el impacto financiero del cambio climático, comprender la exposición de los agentes a los eventos naturales es crucial, aunque desafiante debido a la escasez de datos. Este artículo se centra en evaluar la exposición a riesgos físicos en Chile, utilizando un enfoque novedoso que combina datos de ventas administrativas a nivel micro, información de deuda a nivel de empresa y escenarios de riesgo físico a nivel municipal. El conjunto de datos cubre todas las transacciones de facturas a nivel de empresa en Chile, lo que permite un cálculo preciso de las exposiciones al riesgo físico. Este enfoque granular proporciona conocimientos sin precedentes sobre los impactos potenciales del cambio climático en los sectores económicos, agentes y regiones. Existe una alta concentración de ventas y deuda bancaria en municipios con altos riesgos físicos. Aproximadamente la mitad de las ventas y la deuda se encuentran en municipios que podrían enfrentar episodios de calor extremo en el futuro; este número disminuye al 15% cuando se trata de riesgo de incendio urbano. Este estudio contribuye a cerrar brechas de datos en la investigación relacionada con el clima, ofreciendo una evaluación integral de la exposición a riesgos físicos en los 345 municipios de Chile. Los resultados resaltan el diverso panorama económico de Chile y arrojan luz sobre los desafíos únicos del país, incluida la seguridad del agua, el calor extremo, los incendios urbanos, la generación hidroeléctrica y la mortalidad por calor, enfatizando la necesidad de intervenciones específicas para mejorar la resiliencia económica.

Abstract

Climate change poses significant challenges to economies worldwide, including Chile, where adverse effects are already evident and expected to worsen. To assess the financial impact of climate change, understanding agents' exposure to natural events is crucial yet challenging due to data scarcity. This paper focuses on evaluating exposure to physical risks in Chile, utilizing a novel approach that combines micro-level administrative sales data, firm-level debt information, and physical risk scenarios at the municipality level[2]. The dataset covers all invoice transactions at the firm level in Chile, enabling precise computation of physical risk exposures. This granular approach provides unprecedented insights into climate change's potential impacts on economic sectors, agents, and regions. There is a high concentration of sales and banking debt in municipalities with high physical risks. About half of sales and debt are in municipalities that might face extreme heat episodes in the future, this number decreases to 15% when dealing with urban fire risk. The study contributes to closing data gaps in climate-related research, offering a comprehensive evaluation of physical risk exposures in all 345 municipalities in Chile. Results highlight the diverse economic landscape of Chile and sheds light on the country's unique challenges, including water safety, extreme heat, urban fires, hydroelectric generation, and heat mortality, emphasizing the need for targeted interventions to enhance economic resilience.

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[2] Municipality in Chile corresponds to local governments, that is, institutional units whose fiscal, legislative, and executive authority extends over the smallest geographical areas distinguished for administrative and political purposes.

1. Introduction

Climate change has far-reaching implications for economies across the world, Chile is no exception. Anthropogenic climate change is already causing significant adverse effects, which will deepen in the coming decades under practically any scenario, and which will propagate and amplify risks in the economy (BCBS,2021). A first step towards assessing the financial impact of climate change is to quantify the exposure of agents to the occurrence of adverse natural events, which is a challenge given the shortage of available data (BCBS, 2020). Our paper delves into the task of evaluating the financial repercussions of climate change, with a specific focus on physical risks for Chile. Quantifying agents' exposures to adverse natural events can be a challenge, particularly given the scarcity of granular enough data. To tackle this, we utilize a novel source of information comprised of micro-level administrative sales data obtained from the Chilean tax authority, when combined with firm-level debt, and physical risk NGFS scenarios at the municipality level, it allows for the computation of granular exposures to this type of events. The administrative sales dataset covers the entirety of invoice transactions at the firm level in Chile, allowing for the identification of both sellers and buyers and including all the other characteristics of the transaction. The utilization of granular data permits a precise computation of physical risk exposures across Chile, providing an unprecedented depth of insight into the potential impacts of climate change on various economic sectors, agents, and regions.

Our research connects with the growing strand of literature in climate change impact assessment (NGFS, 2022 and Aurouet et al., 2023). While previous studies have already developed frameworks for assessing physical climate risk, our research distinguishes itself by using a granular micro-level approach that is based on transaction data that includes geographical location of seller and buyer, attaining a fine resolution in the evaluation of physical risks. The unique contribution of our research lies in its application of tax micro-data, providing a novel perspective on the intricate interplay between climate risks and economic activities. Our study sheds light on the unique challenges faced by Chile, a country marked by a diverse geography and a wide array of climatic threats. Our results, coupled with the identification of critical risk factors impacting different economic sectors, serve as a valuable foundation for tailored risk mitigation strategies.

This paper contributes to closing the data gaps in climate-related research. Limited data availability has long been a challenge in the study of climate impacts. Our dataset encompasses the entire country, covering all 345 municipalities in Chile. This exhaustive coverage allows for a comprehensive evaluation of physical risk exposures. The dataset contains the universe of transactions with invoices among firms, providing a robust foundation for our analysis. This enhances the reliability and applicability of our findings, offering insights into the diverse economic landscape of Chile in the face of climate change. This innovative use of administrative data not only increases the precision of our analysis but also sets a precedent for overcoming data gaps in climate research.

The main climatic threats to Chile, given its geography, are coastal deterioration, increased flooding, temperature increases and prolonged droughts (IPCC, 2022). The Northern and Central macro-zones have a high relative exposure to physical risks of coastal deterioration (especially in the Central macro-zone), floods and drought, while the Southern and Metropolitan Region (RM) macro-zones have a much lower exposure to these elements. In particular, the exposure of agricultural properties and business use is higher than the risk in residential housing. Thus, the population of all the properties in Chile faces an exposure of 38.6% to climate change (Cortina and Madeira, 2023).

Thus, in Chile, the northern macro-zones, the metropolitan region (MR) and the center of the country appear to be more exposed to the decrease in the availability of water resources and increases in ambient temperatures. In terms of the climate indicators available in ARClim and CIE, and according to IPCC (2022), the most critical risk factors for the national territory would be urban domestic water security, changes in the electrical grid due to a decrease in water resources, variation in labor productivity due to thermal stress, and increases in maximum daily temperature. This is where our study will focus.

Chile is a highly concentrated country in terms of population settlements and productive activities. According to Córdova et al. (2022), the North, Central and MR macro-zones concentrate 88% of the population, 86% of the firms, 95% of their annual sales, and 90% of the country's GDP. This implies that the direct exposure of households and businesses to the most pressing physical risks for Chile is high, which could exacerbate operating, reinsurance, and credit and market risks. Given this concentration of economic activities in the most exposed macro-zones, if materialized, the impact of physical risks could be significant. Given the concentration of economic activities in the center of the country, together with the vulnerability of the area to an intensification of adverse climatic events, the direct exposure to physical hazards observed would be high. For example, 87% of bank loans are concentrated in regions located in the extreme-risk area for at least one of the dimensions examined, where 59% correspond to commercial loans, 31% to mortgage loans, and 10% to consumer loans. A similar geographic distribution is found in the sales and location of companies throughout Chile, with significant accumulations in the Central and MR macro-zones.

In this paper, by combining the administrative sales and debt data with the physical risk scenarios at the municipality level, we were able to compute granular exposures to adverse natural events for each firm. A pivotal aspect of the methodology is the identification of the firms of supply and use of the goods or services traded, derived directly from the electronic invoices. This level of detail extends beyond the traditional focus on legal company address, offering a more accurate reflection of economic activity as it occurs across firms. After estimating our exposure index, the water safety risk in the central and southern areas dissipates due to the crossing with sales and debt.

Our analysis reveals a notable concentration of billing and debt in municipalities within the metropolitan region, indicating potential economic vulnerabilities to climate change impacts in these areas. Additionally, the physical risk map highlights that municipalities in the central zone of Chile face the highest likelihood of increased water insecurity and extreme heat, with implications for sectors reliant on stable water sources and vulnerable to heat stress. In the northern zone, the municipality of Antofagasta stands out, likely due to the prevalent mining activity in the area, intensifying its exposure to physical risks.

In terms of extreme heat, the exposure rate intensifies in several municipalities. Although the urban fire risks in general are low, when combined with the concentration of sales and debt, the combined exposure index shows an overall deterioration at the national level. Something similar can be seen with Hydroelectric Generation and Heat Mortality indexes. It is worth noting that this exercise does not consider the full range of effects, since it does not consider feedback between sectors, nor future dynamics of reaction to policies.

In summary, our preliminary results provide relevant insights into the potential consequences of climate change on various economic sectors in Chile. Our paper not only introduces a novel approach employing sales micro-level data but also contributes to the broader literature by integrating NGFS climate scenarios and provides insights into the specific challenges faced by Chile. By offering a comprehensive and nuanced assessment of climate-related financial risks and closing data gaps, our study serves as a resource for policymakers, financial institutions, and researchers navigating the complex intersection of climate change and economic resilience.

As we move forward, the preliminary results pave the way for a more in-depth exploration of climate-related financial risks in Chile. The ongoing analysis aims to refine these initial findings, providing a comprehensive understanding of the potential economic impacts and facilitating informed decision-making in the face of a changing climate.

The paper is structured as follows, Section 2 discusses our links with related literature, Section 3 details the data we used for computing exposures, Section 4 describes the methodology for computing exposures, Section 5 summarizes results and Section 6 concludes.

2. Connections with literature

According to UNEP-FI (2018a, 2018b), borrowers' financial health may be at risk due to rising temperatures, droughts, and floods. However, the impact of these climate-related risks on credit risk can vary based on the sector, geography, and reliance on hydropower (NCFA and GIZ, 2017). Therefore, it is crucial to use detailed information to better understand the exposure of these risks (BCBS, 2020; BoE, 2022). Unfortunately, it is challenging to accurately assess firms' exposure to climate risks due to the lack of standardized information about the location of corporate assets and value chain emissions. The heterogeneity of debtors and banks across different regions justifies a more detailed analysis to study the impact of transmission channels on firms, households, and governments with other types of debts (BCBS, 2021).

This paper presents three main contributions. Firstly, we utilize administrative sales data from all Chilean firms at the municipality level. Many studies have focused on listed equities and publicly traded bonds as these securities have readily available data. Consequently, there has been a lack of research on climate exposure of smaller firms.

To determine the optimal location for sales, a thorough assessment of the Chilean territory, considering various elevations, topography, and sensitivities, is essential. Additionally, most physical risk analyses only focus on direct physical damages to properties, infrastructure, and agricultural assets without considering the impact of climate events on factors that affect a company's overall operating environment (NGFS, 2020b). To complement the exposure of assets, we use a company's sales as an indicator to calculate its physical risk exposure.

This document encourages banks to develop and advance their tools for further evaluating their exposure to climate-related risks. Although climate risks can lead to credit, market, liquidity, operational risk exposures, or even bank balance sheet losses, they are not usually considered when assessing credit risk. With the BIS (2021) indicating that climate risks can translate into various forms of financial risks, this assessment of the exposure of Chilean firms to climate risks is a crucial first step in attaining a deeper understanding and more sophisticated tools that will allow for better evaluation of credit risk.

Why is it relevant to assess companies' vulnerability to physical risks?

It has been well documented that extreme weather events can severely impact banks' balance sheets, potentially leading to systemic consequences (ECB, 2019; ECB 2021; NGFS 2020a). The situation is worsened because physical risks may increase rapidly under certain conditions (IPCC, 2018; NGFS, 2020a).

Climate risks can result in traditional financial risks, such as credit and market risks for investors and banks, as well as risks to underwriting and reserving for insurance companies (BIS, 2021; Scott et al., 2017) [3] [4]. Banks can face physical risks depending on the location of the assets they finance or use as collateral. Similarly, climate impacts can affect corporations beyond just the physical exposure of their facilities or branches. This includes disruptions to their supply chains and distribution networks, which can lead to increased operating costs and decreased sales. It can also impact their customers and markets, causing interruptions in the normal development of their operations (EBRD and GCECA, 2018).

Exposure to climate risk may increase credit risk for debtors, reducing their ability to repay debt and banks' ability to recover in case of default (BCBS, 2021; NGFS, 2020b)[5]. This is why financial institutions should consider climate risk when providing loans and incorporate this monitoring in all stages of the loan life (ECB, 2020). Precisely determine how climate risks affect the probability of default (PD) and loss given default (LGD) in sectors or geographies vulnerable to physical risk. The impact may differ significantly across industries and geographic areas.

In addition to traditional financial risks, the ECB (2023) and NGFS (2020b) also highlight fiscal costs. Climate change can potentially impact a country's sovereign risk in several ways. Firstly, it can lead to weak economic activity and damage to infrastructure, which in turn can reduce GDP growth. Secondly, population migration can result from climate change, which can negatively affect a country's economy. Moreover, periods of low growth may require fiscal resources for reconstruction, which can divert money that could be used for research and development (ECB, 2023). According to Buhr et al. (2018), developing countries face increased debt costs due to exposure to climate risk. The study reveals that, on average, the cost of debt has increased by 117 basis points, resulting in an additional $40 billion in interest payments on government debt over the past ten years. The International Monetary Fund (IMF) conducted a study in 2020 to analyze the ten most significant disasters between 1970 and 2018. The study found that emerging markets suffered damage ranging from 2.9% to 10.1% of their gross domestic product (GDP), while advanced

[3] In NGFS (2020b) are detailed 24 categories and subcategories of environmental risks. Each may result in financial risks such as credit (default) risk, market risk (valuation loss), and liquidity risk, as well as operational risk in financial institutions. There are therefore numerous scenarios for environmental risks to transmit to financial risks.

[4] In BoE (2015) it is possible to find a detailed report on the impact of climate change on the insurance sector. The report identifies three risk factors (physical, transition and liability risks) and explores the nature of the risk, the possible impacts on the liability and/or asset side of insurance firms' balance sheets, and the actions firms are taking to mitigate them.

[5] Market risk has also been studied. Market risk is exacerbated if institutions hold assets exposed to multiple climate risks in their portfolios and are forced to sell assets at heavily discounted prices (fire-sales) (ECB, 2022).

economies experienced damages equivalent to 1% to 3.2%. These reductions in GDP may impact how banks assess credit risk at the country level.

Increases in human mortality and decline in labor productivity are other crucial costs related to climate change. These costs are projected to be the primary causes of reductions in output. A study conducted by Carleton and Hsiang (2016) quantifies the impact of climate change on economies. It proves that rising temperatures adversely affect mortality, morbidity, agricultural yields, labor supply, and productivity. Another study by Hsiang et al. 2017 found that the most significant direct cost in the US for global mean surface temperature changes above 2.5°C is the burden of excess mortality, followed by changes in labor supply, energy demand, and agricultural production.

How are physical risks transmitted to the financial sector?

Physical risks can be either acute or chronic (NGFS, 2019a). Acute risks are associated with one-time or sudden climatic events, such as heatwaves, forest fires, disruptions in rainfall patterns, and different types of storms and floods. On the other hand, chronic risks are associated with long-term changes in weather patterns, such as rising sea levels, the planet's average temperature, and the acidification of the oceans. Studies show that these risks can have a detrimental impact on the profitability, sales, and productivity of companies.

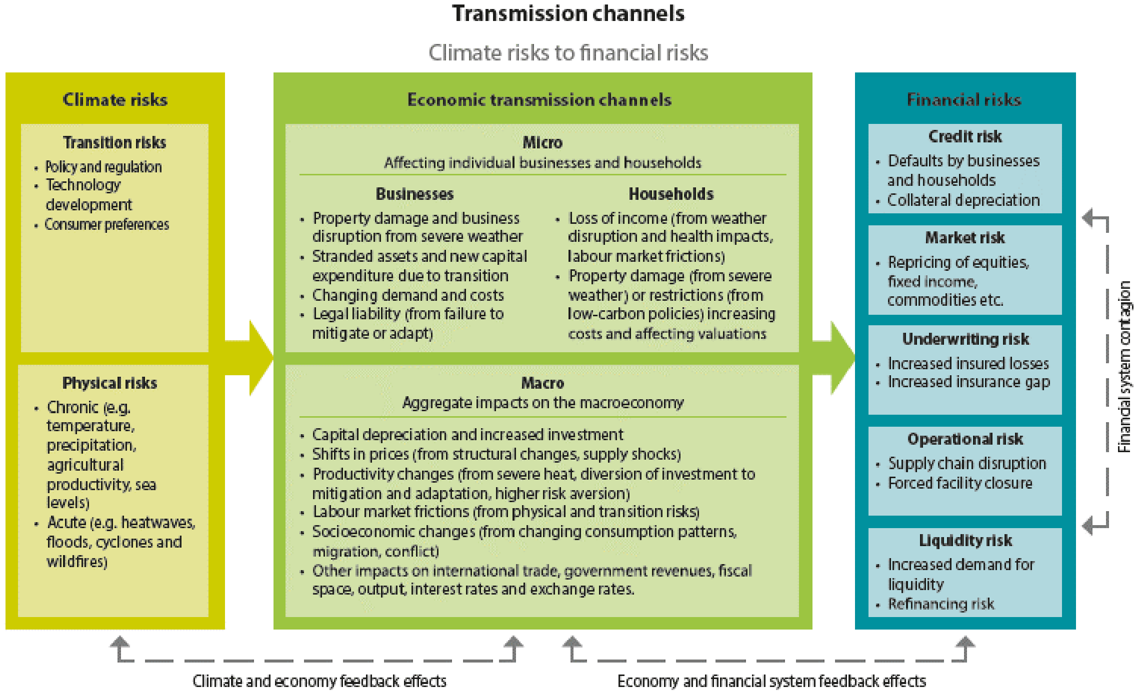
Physical risks are transmitted to the economy and financial system through micro and macroeconomic channels (Hubert et al. 2018; NGFS 2020a; NGFS 2020b; NGFS 2023). Transmission channels are the pathways that describe how climate risk drivers affect banks directly and indirectly through their assets, counterparties, and the economy in which they operate. Research indicates that the effects of these risk drivers on banks are noticeable through conventional risk categories (BCBS, 2021; NGFS, 2023), as illustrated in Figure 1.

Microeconomic channels can have an impact on both homes and businesses.

- Households may experience a loss of income due to disruptions in economic activity caused by climate change. In addition, weather disruptions can impact health, including decreased labor productivity, mortality, and morbidity resulting from changes in temperature extremes. Furthermore, households can also face physical damage or loss of valuation due to asset destruction caused by events such as floods or windstorms.

- Businesses may experience a loss in revenue due to direct damage or supply chain disruptions, as well as a reduction in agricultural yields or labor productivity. Additionally, companies may face higher costs from investing in adaptation. Real estate and other infrastructure are particularly vulnerable to specific hazards, such as flooding in coastal areas, which can result in a decline in the collateral values of borrowers.

Figure 1



Source: NGFS (2023)

Macroeconomic channels have an aggregate effect on the economy. Among the main channels are productivity, migration, reconstruction and replacement of infrastructure, capital replacement, investment, structural changes in the markets, socio-economic changes, etc. (NGFS, 2020a). Given the microeconomic orientation of this document, we will not go into further detail. However, interested readers can refer to NGFS (2019b), NGFS (2023), and ECB (2023).

Climate risks translate into traditional financial risks. The main one that interests us is credit risk. This risk arises from direct exposures of financial institutions to affected firms through lending or asset holdings as collateral. Physical risks directly affect firm revenues and operating expenses (Alogoskoufis et al., 2021). Natural catastrophes generate physical capital losses, which might eventually require additional investments, exerting upward pressure on leverage. At the same time, revenues would decrease as the physical capital losses would result in a decline in production capacity and productivity (NGFS, 2019b). It can also be mentioned that supply-chain links or lower demand and higher unemployment can occur because of a more generalized economic downturn.

The impact of physical risk will also depend on the geographical location. Significant differences exist in the distribution of the economic effects of physical risks across regions and sectors. This variation is driven by differences in the gross exposure to physical risks and the level of resilience and adaptation (action taken to prevent or minimize damage). Countries with less economic diversification, climate-resilient public infrastructure, capital market flexibility, and lower adaptation capacity will be at greater risk. Some sectors could be at greater risk, too, depending on their regional footprint. Granular data are also needed to conduct bottom-up, quantitative analysis of the macro-financial impacts of climate-related risks (NGFS, 2019).

Finally, the nature of the financial risks will also depend on the price and availability of insurance. If losses are insured, they can directly affect insured and reinsurance firms through higher claims. If losses are not insured, the burden can fall on households, corporations, and governments. This can impair asset values, reduce the value of investments held by financial institutions, and increase credit risk for banks and investors (NGFS, 2023).

Measuring exposures to physical risks in Chile

Hernández and Madeira (2021) study the impact of precipitation and temperatures on GDP using region-industry panel data for Chile from 1985-2017. They found no effect of precipitation changes on GDP, but the results confirm a negative impact of higher summer temperatures on agriculture, silviculture, and fishing. Using similar information but in a different time window, Reszczynski (2024) studies the relationship between climate change and GDP through a regional-industrial panel for Chile between the first quarter of 1997 and the fourth quarter of 2019. She finds that an increase in temperature has a negative impact and is significant in economic activity for most industries in Chile's GDP. Also, she finds that a drop in precipitation negatively affects activity but only in the agricultural-forestry industry. These two studies reveal the heterogeneity in the impacts that climate change can generate on the Chilean economy.

Madeira (2022) presents a comprehensive review of several studies related to the future impact and effects estimated of climate change during the twenty-first century for Chile. The results suggest - with substantial uncertainty around these estimates - that Chile will likely suffer mild effects on GDP growth, labor productivity, and mortality costs. However, it could also experience significant water stress and scarcity due to low precipitation, fire hazards, and air pollution. It is also expected to significantly increase migration towards Chile from poorer neighboring countries that may be strongly affected by climate change.

Córdova et al. (2022) show that the impact of physical risks could be significant given the concentration of economic activities in the most exposed macro-zones. Using a mix of micro and aggregated data, they find that the northern macro-zones, the Metropolitan Region (RM), and the country's center appear to be more exposed to the decrease in the availability of water resources and increases in ambient temperatures[6]. This situation worsens if the North, Central, and RM macro-zones concentrate 88% of the population, 86% of the firms, 95% of their annual sales, and 90% of the country’s GDP. This implies that the direct exposure of households and businesses to Chile's most pressing physical risks is high, which could exacerbate operating, reinsurance, credit, and market risks. For example, 87% of bank loans are concentrated in regions located in the extreme-risk area for at least one of the dimensions examined, where 59% correspond to commercial loans, 31% to mortgage loans, and 10% to consumer loans. A similar geographic distribution is found in the sales and location of companies throughout Chile, with significant accumulations in the Central and RM macro-zones. Using this document, in the present paper, we refine the exposure calculation using microdata at the community level.

[6] According to IPCC (2022), the most critical risk factors for the national territory would be urban domestic water security, changes in the electrical grid due to a decrease in water resources, variation in labor productivity due to thermal stress, and increases in maximum daily temperature.

Cortina and Madeira (2023) perform a quantification exercise of real estate properties exposed to climate risks using microdata to compute territorial exposure to physical hazards. For this purpose, the properties listed in the Real Estate Cadaster (georeferenced by district) are associated with climate exposure indicators referring to the loss of labor productivity in the event of heatwaves, fires, floods, drought, and coastal deterioration. It has been found that over 30% of property valuation in Chile is exposed to climate risks up to 2050 (under the assumption that current policies are maintained). The Northern and Central macro-zones have high relative exposure to physical risks of coastal deterioration (especially in the Central macro-zone), floods, and drought. In contrast, the Southern and RM macro-zones have much lower exposure to these elements. In particular, the exposure of agricultural properties and business use is higher than the risk in residential housing.

Beltran et al. (2023) summarize the results from several studies that quantify the impacts of climate change in Chile, emphasizing both the macroeconomic and sectoral effects of higher temperatures and other climate events. The review highlighted the need to expand the analytical efforts to quantify the impacts of climate change in Chile along three main dimensions: geo-referencing of physical and financial assets, characterization of the transmission channels through which climate shocks can spread throughout the economy, and accounting for the fact that climate events are not stationary.

Measuring exposures to climate physical risks: a focus on the work of central banks[7]

Several central banks have tried to measure their financial system's exposure to climate risks, focusing mainly on banks and insurance companies. For example, De Nederlandsche Bank (2017) examines the consequences of climate change for insurers and the impact of large-scale flooding on the Dutch financial sector. They conclude that the most significant economic losses from climate disasters could occur due to flooding caused by rising sea levels. This is because the affected assets are not fully insured and are only partly compensated by the government. There is a small probability of such an event occurring but with a significant impact. In this scenario, losses could reach 60 billion euros.

The European Central Bank (2021) estimates the banking system's exposure to climate risk. Using a sample of 1.1 million firms, they conclude that many firms are exposed to climate risk in different geographic areas. Floods are relevant in central and northern Europe, where around 7% of firms are exposed to this risk. In southern Europe, 18% of firms are exposed to heatwaves, water stress, or fires. Regarding lending, around 30% of the European banking system is exposed to non-financial firms with a high or increasing risk of at least one physical risk.

Banco de España (2021) uses the Orderly Transition scenario and the Hot House World scenario to evaluate the impact of physical risks on the banking sector, following the recommendations of the NGFS. At the beginning of the projection, the transition costs exceed the physical costs, so the firms' credit risk of default is somewhat higher in the Orderly scenario. However, this situation is reversed in the long term due to materializing physical risks, so the risk of default is more significant in the Hot House World scenario. In 2070, the probability of default for households was 0.57pp higher in

[7] Given the extensive international literature, we have decided to focus on studies carried out by central banks. Like our work, these studies are characterized by covering many firms with an emphasis on financial stability.

the Hot House World scenario compared to the Orderly Transition scenario, with this difference increasing to 1.11pp for firms. The report indicates that even though these differences in the two scenarios may seem marginal, they are relevant since they show a permanent deterioration in the quality of the portfolio. This has a relevant impact when this deterioration accumulates throughout the loan's life.

Danmarks NationalBank (2021) shows that flood risk could affect a significant part of its financial institutions. This is due to the properties used as collateral for loans, which could be flooded and are in the same geographic area. These exposures account for kr. 41 billion today, which could increase to kr. 198 billion by the end of this century. The report indicates that financial institutions should incorporate this climate and geographic concentration risk into their portfolio management.

Banco de Portugal (2023) uses the Net-zero 2050, Delayed Transition, and Current Policies climate scenarios to carry out the climate risk analysis of the banking system. This work has a high degree of granularity in the information, including (i) GHG emissions, (ii) exposure to physical risk events, considering the geographical location, and (iii) the firm's financial situation. The banks' exposure is measured through the loans provided. Exposure to climate risk is mainly explained by water, heat, and fire stress. The exposure of firms to flood risk is significant, reaching 38% of total loans. On the contrary, exposure related to sea level rise, hurricanes, or typhoons is low.

The results of the 2021 Climate Biennial Exploratory Scenario (CBES, Bank of England (2022)) show the financial risks posed by climate change for the largest UK banks and insurers. In this exercise, three scenarios are proposed, of which they highlight the NAA (No Additional Action) scenario due to the impact generated by physical risks. Under this scenario, essential costs are identified for banks and insurers during the projection horizon. This is because heightened physical risks lead to higher losses on loans and insurance and lower returns on financial assets. Impairment rates projected by banks were just over 50% higher than normal levels but with high uncertainty. Banks appeared less equipped to assess the impact of physical risk, particularly those arising from corporate vulnerabilities. The aggregate results show that, for life and general insurers, the NAA scenario would likely have a more significant impact than either of the transition scenarios, even within the 30-year window of the exercise.

3. Data[8] [9]

a. Administrative sales data [10]

The administrative sales data obtained from the Chilean tax authority cover the entirety of invoice transactions at the firm level in Chile for 2022, allowing for the identification of both sellers and buyers, and their geographical location. Obtained from electronic invoices (EI), this dataset presents a groundbreaking approach to capturing the economic pulse at the municipality level. This data allows us to explore transactions of goods and services between companies, emphasizing the specific locations of these transactions rather than the broader regional scope traditionally reported. By leveraging the granularity of electronic invoicing data, the dataset illuminates the intricate web of economic activity within and between firms, offering insights into the flow of goods and services across the fabric of the local economy.

This approach considers internal sales exclusively, sidelining international transactions to focus squarely on the domestic economic landscape. Importantly, the analysis does not differentiate between the ultimate use of the goods sold, encompassing both intermediate inputs like raw materials and capital goods such as machinery and vehicles. This broad inclusion criterion ensures a comprehensive overview of the goods and services flowing through firms.

A pivotal aspect of the methodology is the identification of the firms of supply and use of the goods or services traded, derived directly from the electronic invoices. This level of detail extends beyond the traditional focus on legal company address, offering a more accurate reflection of economic activity as it occurs across firms.

With the aim of facilitating the presentation, the following table presents a summary of the information at the regional level for December 2022[11]. It shows the number of sellers and buyers, the volume of transactions within and between regions, and the total sales in millions of USD for both intra-regional and inter-regional exchanges.

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[8] *This study was developed within the scope of the research agenda conducted by the Central Bank of Chile (CBC) in economic and financial affairs of its competence. The CBC has access to anonymized information from various public and private entities, by virtue of collaboration agreements signed with these institutions.*

[9] *To secure the privacy of workers and firms, the CBC mandates that the development, extraction and publication of the results should not allow the identification, directly or indirectly, of natural or legal persons. Officials of the Central Bank of Chile processed the disaggregated data. All the analysis was implemented by the authors and did not involve nor compromise the SII and the CMF.*

[10] *The information contained in the databases of the Chilean IRS is of a tax nature originating in self-declarations of taxpayers presented to the Service; therefore, the veracity of the data is not the responsibility of the Service.*

[11] To fulfill the objectives of government and administration, the country is divided into sixteen smaller territorial units called Regions. The regions are divided, in turn, into provinces and these are finally divided into municipalities (source: División Política-Administrativa — (bcn.cl)).

Table 1. Intra-Regional and Inter-Regional economic transactions overview

Region*	Sellers (in thousands)	Buyers** (in thousands)	Number of Electronic invoices issued (in thousands)			Total sales (in millions of USD)		
			Intraregional	Interregional	Total	Intraregional	Interregional	Total
Arica y Parinacota (4)	5,5	19,0	144	40	184	58	52	111
Tarapacá (7)	8,1	38,5	266	86	352	186	145	330
Antofagasta (9)	16,3	54,2	568	189	758	428	907	1.335
Atacama (9)	7,4	25,7	236	82	318	146	185	331
Coquimbo (15)	19,2	72,2	631	204	836	286	323	609
Valparaíso (38)	46,3	196,2	1.582	664	2.246	840	1.942	2.782
Metropolitana (52)	236,4	892,8	13.901	5.903	19.803	22.907	6.038	28.944
O'Higgins (33)	27,0	94,9	749	289	1.038	767	785	1.553
Maule (30)	32,9	107,2	1.018	514	1.531	763	603	1.366
Ñuble (21)	12,2	45,8	389	211	599	178	270	448
Biobío (33)	39,1	138,1	1.299	437	1.736	854	1.060	1.915
La Araucanía (32)	25,4	85,6	862	324	1.186	444	395	839
Los Ríos (12)	11,9	40,6	310	152	462	155	231	386
Los Lagos (30)	30,4	95,9	1.196	333	1.529	1.012	525	1.537
Aysén (10)	4,7	14,2	133	28	161	48	35	83
Magallanes (11)	6,6	19,6	247	36	283	137	101	238
National level	526,4	1751,2	23.531	9.492	33.023	29.208	13.598	42.807

* Next to each region, within parentheses, the number of municipalities comprising it is indicated.
** The number of buyers includes natural persons, who do not issue electronic invoices.
***1USD=875,66$ (source: Base de Datos Estadísticos (BDE))

Table 2 provides a detailed view of the transactional dynamics of two enterprise categories for December 2022. It illustrates how sales volumes, and the distribution of electronic invoices vary by company size and transaction type. This detailed categorization helps to highlight the significant roles played by Micro, Small, and Medium Enterprises (MSMEs) and large enterprises in shaping the economic landscape, providing a clear depiction of their contributions across regions.

Table 2. Enterprises by business size

Enterprises	Annual sales	Sellers	Buyers*	Number of Electronic invoices issued *(In thousands)*			Total sales *(In millions of USD)*		
	(USD)	*(In thousands)*	*(In thousands)*	MSME	Large	Total	MSME	Large	Total
MSME	Up to 4 million	513,4	1.735,50	9.122	2.295	11.417	5.481	5.793	11.274
Large	4 million or more	13,1	15,7	16.252	5.354	21.606	6.891	24.641	31.532
National level		526,4	1.751,20	25.374	7.649	33.023	12.372	30.434	42.807

* Micro, Small, and Medium Enterprises (MSME)
**1USD=875,66$ (source: Base de Datos Estadísticos (BDE))

This innovative approach to analyzing economic activity through electronic invoices at the municipality level provides a new perspective on the local economic landscape. By mapping the flow of goods and services with such specificity, it enhances our understanding of local economies and offers valuable insights for policymakers, businesses, and researchers. The project's use of technology to explore the microcosm of economic activity marks a new era of economic analysis, highlighting the local nuances of trade and commerce and offering a richer, more detailed portrait of the country's economic activity.

It should be noted that in our analysis and as a robustness exercise we will use two sales measures. The one we just described and the total sales of the firm. The latter also include exports and sales made through receipts.

b. Physical Risks in Chile

ARClim, the Climate Risk Atlas for Chile, it's a project of the Ministry of the Environment of the Government of Chile, developed by the Climate and Resilience Research Center (CR2) and the Center for Global Change (CCG-Catholic University of Chile) with the collaboration of other national and international institutions. ARCLim was supported by the Global Risk Assessment and Management Program for Climate Change Adaptation (Loss and Damage) commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). The objective of this project is to collaborate with the Ministry of Environment of the Government of Chile, contributing to the strengthening of national capabilities in the face of the challenges of climate change in the country.

The ARClim project developed risk maps related to climate change for Chile, incorporating historical climate projections (period 1980-2010) and future (30-year multidecadal period, centered on 2050, under a scenario of high greenhouse gas emissions, RCP8.5). The maps communicate information on Threats, Exposure, Sensitivity and Risk of the selected national systems, at the community level.

The evaluated climate risk represents an indicator of the magnitude of damage that could be expected in the face of a change in climatic conditions. Each map is the result of the combination of the climate threat (T), exposure (E) and sensitivity (S) of the municipality. These three variables (T, E, S) are combined to determine the risk due to climate change. In Annex 1.1 there are the maps (impact chains) with de Estimating Risk (R) organized into five physical risks.

- Water Safety: This map represents the variation in negative impacts on the health of the urban population of each municipality, between the historical period and the future due to the change in the incidence of meteorological droughts and potential evotranspiration. The map is a graphic visualization of the risk index for each municipality. The index does not represent the probability of impacts occurring, but only which municipalities show willingness to suffer adverse impacts associated with urban domestic water insecurity under historical and/or future climatic, social, and institutional conditions. The index has a range between 0 and 1 and takes higher values (generating a darker color on the map) in communes in which a high incidence of urban domestic water insecurity conditions is recorded, a significant proportion of the urban population resides in which high conditions of demographic, household, health and territorial services sensitivity are observed, along with reduced social and institutional capacities to respond or adapt to these impacts.

  In this map it can be identified that the municipalities where the risk of water insecurity would increase the most correspond to those of the Valparaíso and Metropolitan regions of Santiago. Furthermore, in the Libertador Bernardo O'Higgins and Maule regions, the risk increases to very high for some municipalities distributed heterogeneously within the regions. On the other hand, a high risk is identified in some communes in the Coquimbo Region, mainly the coastal ones and in certain communes in the Bio-Bio and Los Ríos regions. A moderate increase in the risk of urban domestic water insecurity was shown by the Atacama and Araucanía regions and from Los Lagos to the south of the country. Finally, in the extreme north and south of the country, a risk reduction from low to very low was identified.

- Extreme Heat: This map represents the variation in the risk of health impacts because of heat waves, between the historical period and the future. The change in risk only considers the change in the threat (increase in heat waves), under conditions of future exposure and historical sensitivity and resilience. The index does not represent the probability that impacts will occur, but only which communes show willingness to suffer adverse impacts associated with heat waves under historical and future climatic, social, and institutional conditions. The index has a range between 0 and 1 and takes higher values (generating a darker color on the map) in communes in which a high incidence of heat wave conditions is recorded, a significant proportion of the population resides (urban or rural) and in which high conditions of territorial and/or population sensitivity are observed, together with reduced social and institutional capacities to respond to and mitigate these impacts.

  As can be seen in the map, the greatest increases in risk are recorded in the central-southern and southern areas, and especially marked in the Metropolitan Region For the rest, a slightly more uniform risk distribution is observed with municipalities with slightly high risk (“orange”) both in the north-central-RM zone and low (“green”) in the south zone.

- Urban Fires: The Impact Chain analyzes the risk of fire in urban settlements in all the communities of the country. Considers the variation in the incidence of temperatures above 30ºC, the urban population that is projected to reside in the country's municipalities in 2035, the percentage of homes with an “unrecoverable” and “recoverable” materiality index, and the communal rate of number of companies of firefighters per 100,000 inhabitants. From the physical risk map, some exposure can be observed in municipalities in the central area of the country and some more exposed in the northern area. However, in general the exposure to this risk is low.

- Hydroelectric Generation: The maps represent the impact chain and the risk of increased marginal costs of the electrical system associated with the decrease in water resources of the country's main hydroelectric generation plants because of climate change. The index takes high values in communities with high connected electricity consumption where their electricity supply needs to compensate for electricity generation using other more expensive resources. On the map it can be identified that the municipalities where the risk of water insecurity would increase the most are in the central zone and in the metropolitan region. Furthermore, in the regions immediately to the south, the risk increases to very high for some communes distributed heterogeneously within the regions. On the other hand, a high risk is identified in some coastal communes in the lower north. A moderate increase in the risk of urban domestic water insecurity was shown in the northern and southern regions of the country. Finally, in the extreme north and south a risk reduction from low to very low was identified.

- Heat Mortality: The risk is characterized as the increase in population mortality due to the change in temperature from the base period (1980-2010) to the future period (2050, as an average of the projected temperature for the years 2035-2064). The map shows communal premature mortality, which corresponds to the number of deaths from non-accidental causes expected by the year 2050, considering an increase in temperature due to climate change. This map shows that the exposed municipalities are in the central and northern areas of the country (orange and red colors).

c. Administrative debt records:

The administrative debt records come from the "Debtors System" file of the Financial Market Commission as of December 2022. Collapsed information is available per debtor for direct debts related to commercial credits transactions that a particular debtor has with the banking system[12]. This information corresponds to the universe of firms with legal personality in Chile.

In general, as expected considering the business model of banks, sales and debt show high spatial correlation (**Figure 2.1**). In terms of physical risks, most of debt and sales are usually located in municipalities where water safety risk is high (**Figure 2.2**). However, when it comes to extreme heat, there is a more even distribution across geographical areas (**Figure 2.3**). Related to the previous aspect, the risk of heat mortality is higher in areas that concentrate more debt and sales, as a reflection of the concentration of added value in the Metropolitan Region (**Figure 2.4**). Regarding urban fires, they have a low prevalence as physical prospective risk, most municipalities with high sales and debt are located away from these areas (**Figure 2.5**). About hydroelectric generation, one major source of electricity in Chile where near a quarter of the total is linked to this technology, most municipalities are in areas with low risk of increases in the marginal cost of generation (**Figure 2.6**).

As a first exercise we split all 345 municipalities equally into three groups (terciles) under each of the five physical risks we are considering, namely: water safety, extreme heat events, urban fires, heat mortality and hydroelectric generation difficulties. These terciles define thresholds for each risk dimension, so we label these regions as low, medium, and high risk. Results are in **Tables 2a and 2b**, based on the location of the seller and buyer, respectively. We find that for water safety risks about 74% of the sales are associated to sellers located in high-risk areas, this share climbs to 77% when calculated using the location of the buyer, so there does not seem to be much diversification of this particular risk from the sellers' point of view. Concentration is lower when it comes to urban fire risks, for both sales and debt, either from the point of view of the buyer or seller, this share amount to about 15%. These results point to high concentration is some dimensions of physical risks and to high heterogeneity across risks. Also, they suggest that there is room for diversification for sellers, in terms of the physical risks faced by their buyers.

The administrative sales records show a significant concentration of billing in municipalities in the metropolitan region, where it is possible to observe a significant concentration of municipalities in darker colors (Annex 1.1.2). While in the north, one municipality in particular, Antofagasta, stands out highly probably due to mining activity in the area (Annex 1.1.1). A similar situation can be observed in

[12] More information about the characteristics of the debtor file used, see the "Debtor System" manual, section D10 file, available at: https://www.cmfchile.cl

terms of debt concentration.

4. Methodology

Through these indicators we can identify those municipalities most likely to suffer the impacts of droughts, wave heaths, fires, and hydroelectric dependence and indirectly through the administrative records of sales and debt those companies most exposed. As mentioned in BCBS (2021) droughts may pose a greater risk to the financial health of borrowers affecting firms in terms of production, supply chains and lower demand.

To compute physical risk exposures at the municipality level, we began by collecting micro-level administrative sales data. Next, we integrated this administrative sales data with firm-level debt data information. This integration allowed us to link sales data to specific firms and their debt profiles.

We then utilized physical risk scenarios developed by the ARClim at the municipality level. The future climate is not a prediction, but a projection based on a scenario of intense greenhouse gas emissions (NGFS RCP8.5)[13]. These scenarios provide estimates of the likelihood and severity of adverse natural events, such as floods, droughts, and extreme temperatures, occurring in each municipality.

By combining the administrative sales data and debt with the physical risk scenarios at the municipality level, we were able to compute granular exposures to adverse natural events for each firm. This involved assessing the probability and potential impact of each event on the firm's operations, revenues, and financial health.

Finally, we analyzed the computed exposures to identify patterns in physical risk across different regions in Chile. This analysis provided insights into the potential impacts of climate change on the economy and guided the development of risk mitigation strategies.

To compute the exposure to physical risk by municipality we define:

$$e_{it} = ln\,(r_{it} * f_{it})$$

Where r_{it} is a dimension of physical risk for municipality i in the period t, f_{it} is a real or financial characteristic and e_{it} is the exposure. Both r_{it} and f_{it} are rescaled to lie within the unit interval.

5. Results

Physical Risks and Financial variables

Water Safety – Sales (administrative/total) – *Debt (Annex 1.2.1 – 1.2.1.2)*
After estimating our exposure index, the high physical risk in the central and southern areas dissipates

[13] Representative Concentration Pathways (RCPs). This high-emissions scenario if frequently referred to as "business as usual", suggesting that is a likely outcome if society does not make concerted efforts to cut greenhouse gas emissions. Compared to the total set of RCPs, RCP8.5 corresponds to the pathway with the highest greenhouse gas emissions.

due to the crossing with sales and debt. The Metropolitan Region maintains its high exposure due to both indicators (physical and financial). While in the north, one commune in particular, Antofagasta, is clearly intensifying, highly likely to mining activity in the area.

Extreme Heat – Sales (administrative/total) – *Debt (Annex 1.2.2)*
The exposure rate intensifies in several municipalities. In the northern area it is observed that several go from low to intermediate risk (green to yellow) and those from intermediate risk to slightly high risk (yellow to orange). In the central zone, the upper-intermediate municipalities intensify their index, mainly in the metropolitan region. In the southern zone, several low-risk communes increase to intermediate (green to yellow). In summary, the sales and debt of Chilean firms are exposed to the physical risk of extreme heat in the northern and central zone.

Urban Fires – Sales (administrative/total) – *Debt (Annex 1.2.3)*
Although the physical risk in general is low (Annex 1.1), when combined with the concentration of sales and debt, the combined exposure index shows an overall deterioration at the national level.

Hydroelectric Generation – Sales (administrative/total) – *Debt (Annex 1.2.4)*
The concentration of sales and debt explains a general deterioration in the risk index, especially in the central and northern areas of the country.

Heat Mortality – Sales (administrative/total) – *Debt (Annex 1.2.5)*
The index shows that in the central zone the municipalities reduce their exposure, something similar can be seen in the northern zone. However, here it is possible to observe that darker colors tend to predominate, which would indicate greater exposure of the firms' sales and debt to this physical risk.

6. Final remarks

Climate change poses significant challenges to economies worldwide, including Chile. Our study focuses on evaluating the financial repercussions of climate change, specifically addressing physical risks in Chile. By utilizing a unique dataset comprised of micro-level administrative sales data from the Chilean tax authority, combined with firm-level debt and physical risk scenarios developed by ARClim based on NGFS scenarios at the municipality level, we were able to compute granular exposures to adverse natural events for each firm.

Our analysis reveals a notable concentration of billing and debt in municipalities within the metropolitan region, indicating potential economic vulnerabilities to climate change impacts in these areas. Additionally, the physical risk map highlights that municipalities in the central zone of Chile face the highest likelihood of increased water insecurity and extreme heat, with implications for sectors reliant on stable water sources and vulnerable to heat stress.

The exposure index shows that while some municipalities reduce their exposure when considering sales and debt, the Metropolitan Region maintains its high exposure due to both physical and financial indicators. In the northern zone, the municipality of Antofagasta stands out, likely due to the prevalent mining activity in the area, intensifying its exposure to physical risks.

Our results are robust to using different sources of sales data, such as microdata for invoices and official administrative tax records, enhancing the reliability and applicability of our findings.

Further analysis is needed to explore if banks have reacted and changed their exposure to certain zones more affected by physical risk. This work is still in progress and will provide additional insights into the financial sector's response to climate change impacts in Chile.

Overall, our study will provide valuable insights into the potential consequences of climate change on various economic sectors in Chile. By offering a comprehensive and nuanced assessment of climate-related financial risks and closing data gaps, our study serves as a resource for policymakers, financial institutions, and researchers navigating the complex intersection of climate change and economic resilience.

As we move forward, further analysis and refinement of these initial findings will provide a deeper understanding of the potential economic impacts of climate change in Chile, facilitating informed decision-making and the development of targeted risk mitigation strategies.

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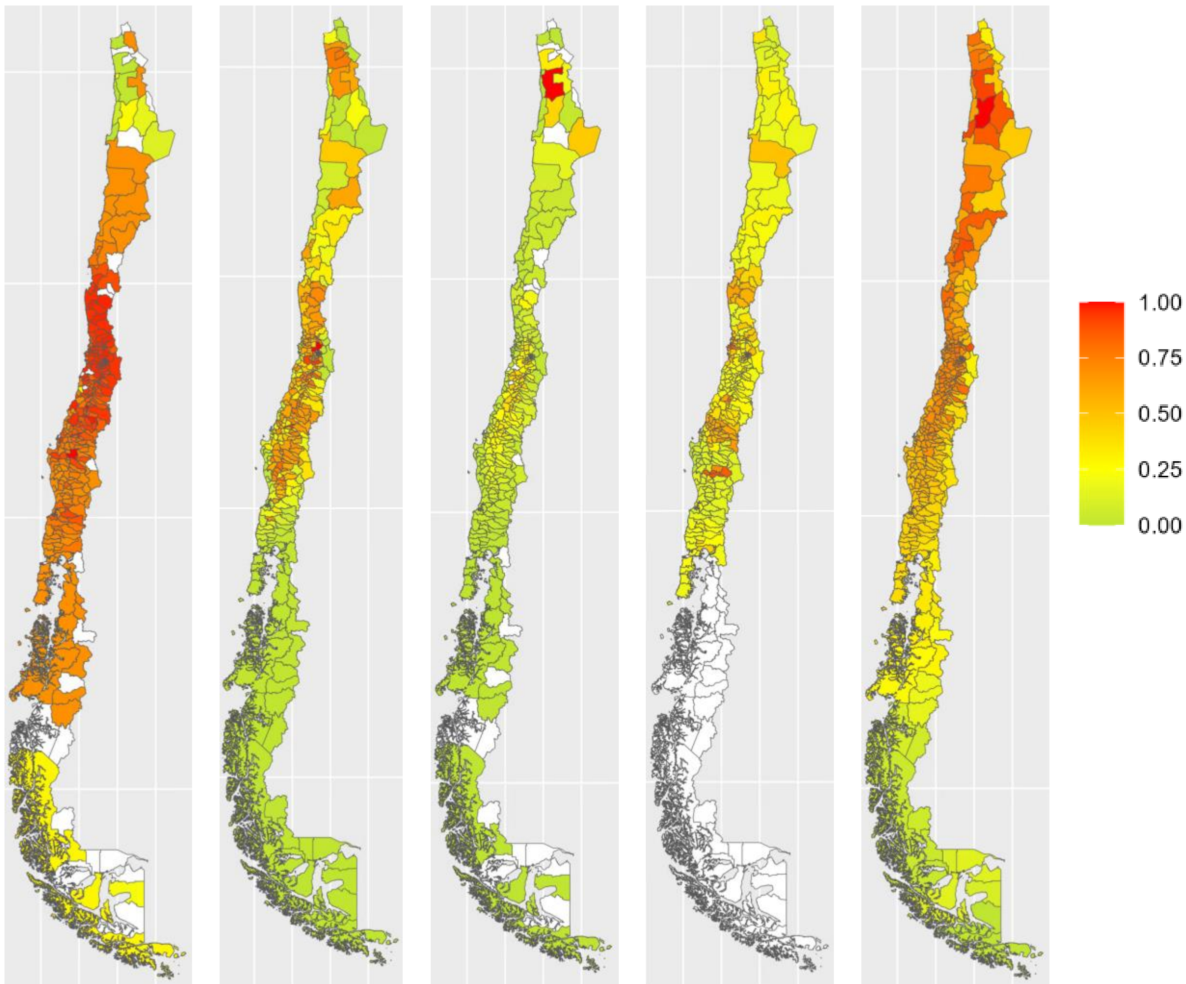
Annexes

1.1 Physical Risks in Chile

Water Safety: **Extreme Heat:** **Urban Fires:** **Hydroelectric Generation:** **Heat mortality:**

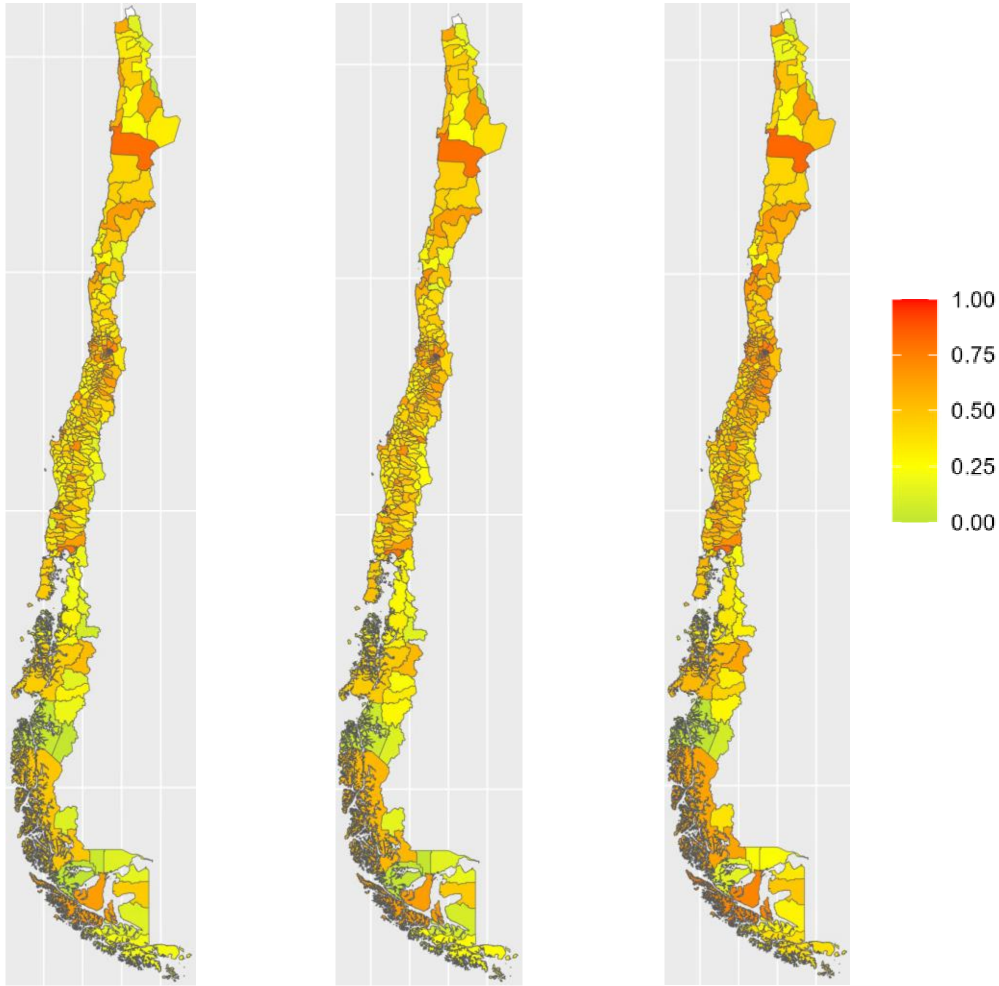


Source: Central Bank of Chile based on ARClim data.

1.1 Financial variables

1.1.1 Chile

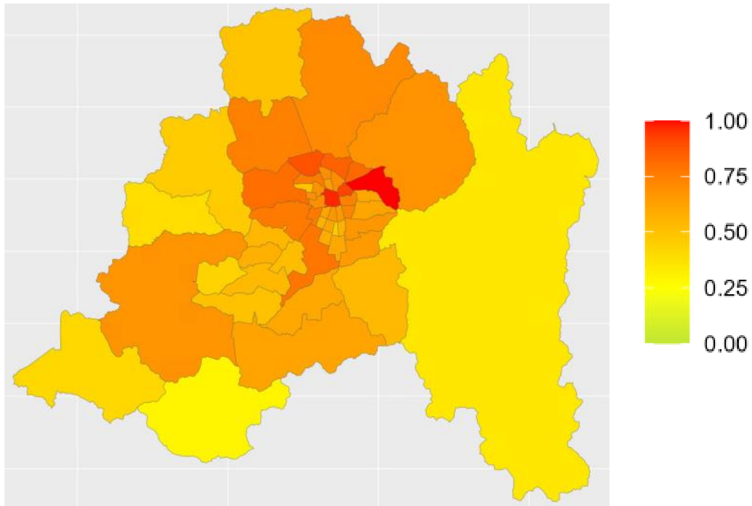
Administrative Sales: **Total Sales:** **Total Debt:**



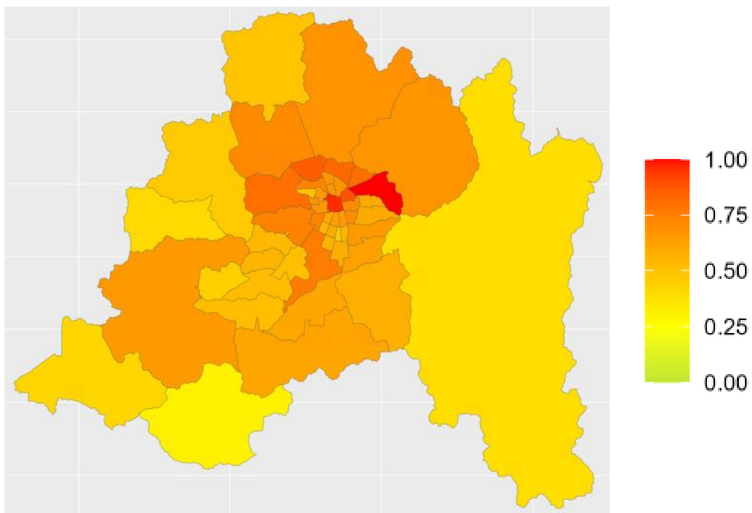
Source: Central Bank of Chile based on SII (Chilean tax authority) data.

1.1.2 Metropolitan area

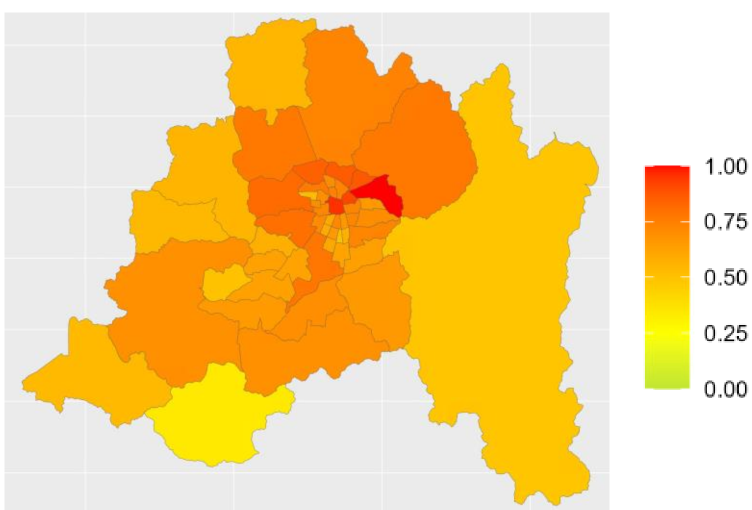
Administrative Sales:



Total Sales:

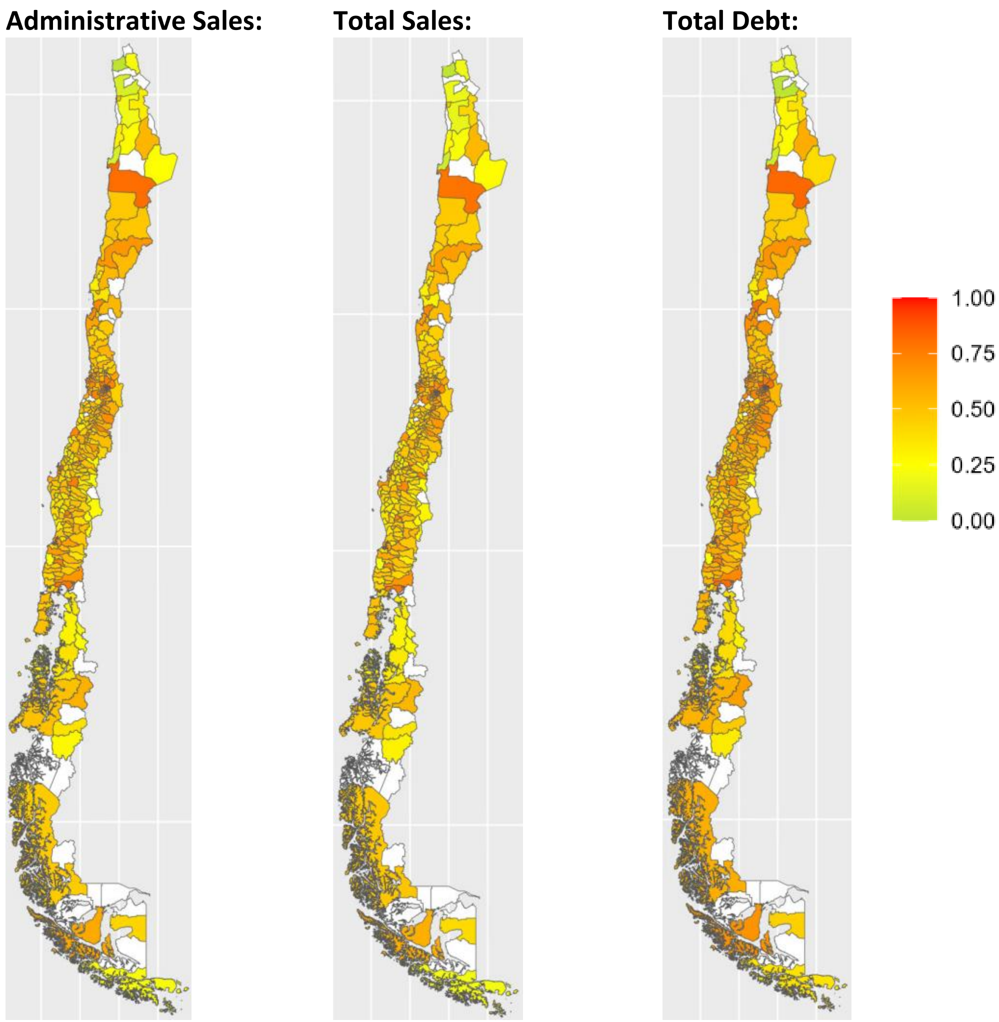


Total Debt:



Source: Central Bank of Chile based on SII (Chilean tax authority) data.

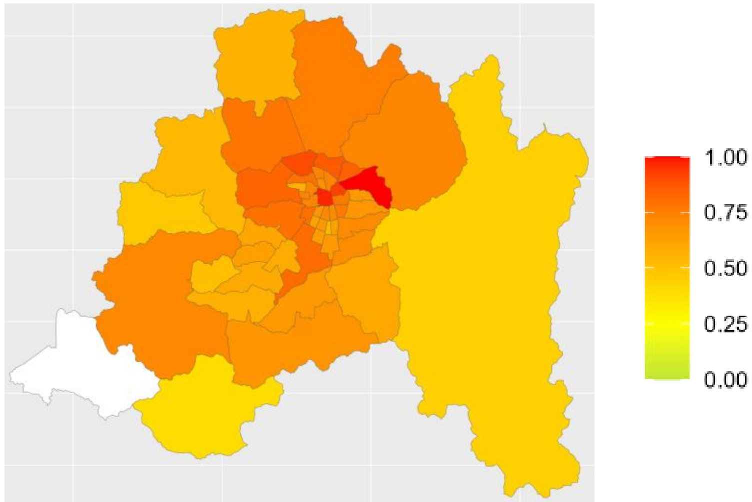
1.2 Physical Risks – Financial variables
1.2.1 Water Safety
1.2.1.1 Chile



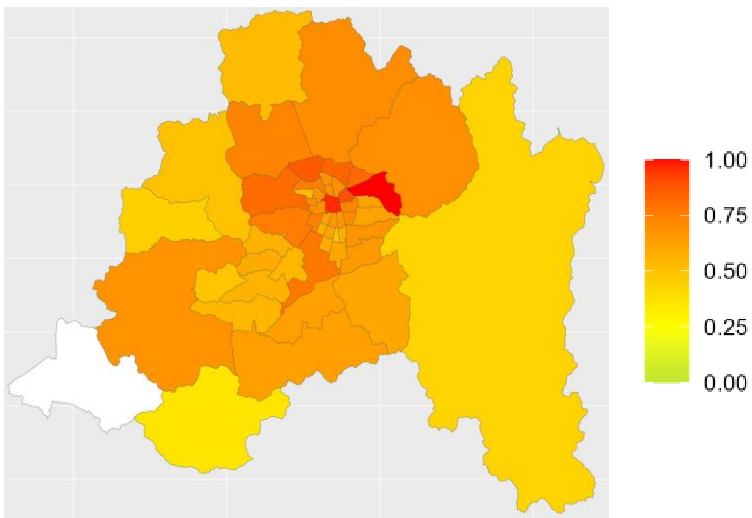
Source: Central Bank of Chile based on SII (Chilean tax authority) and ARClim data.

1.2.1.2 Metropolitan area

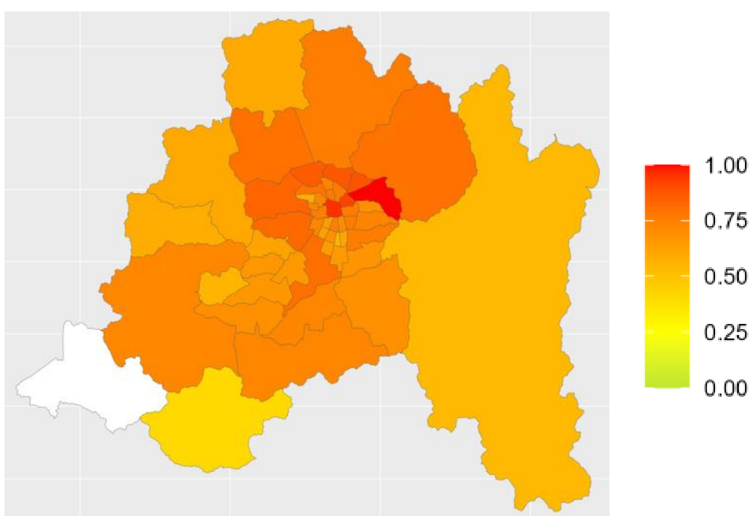
Administrative Sales:



Total Sales:

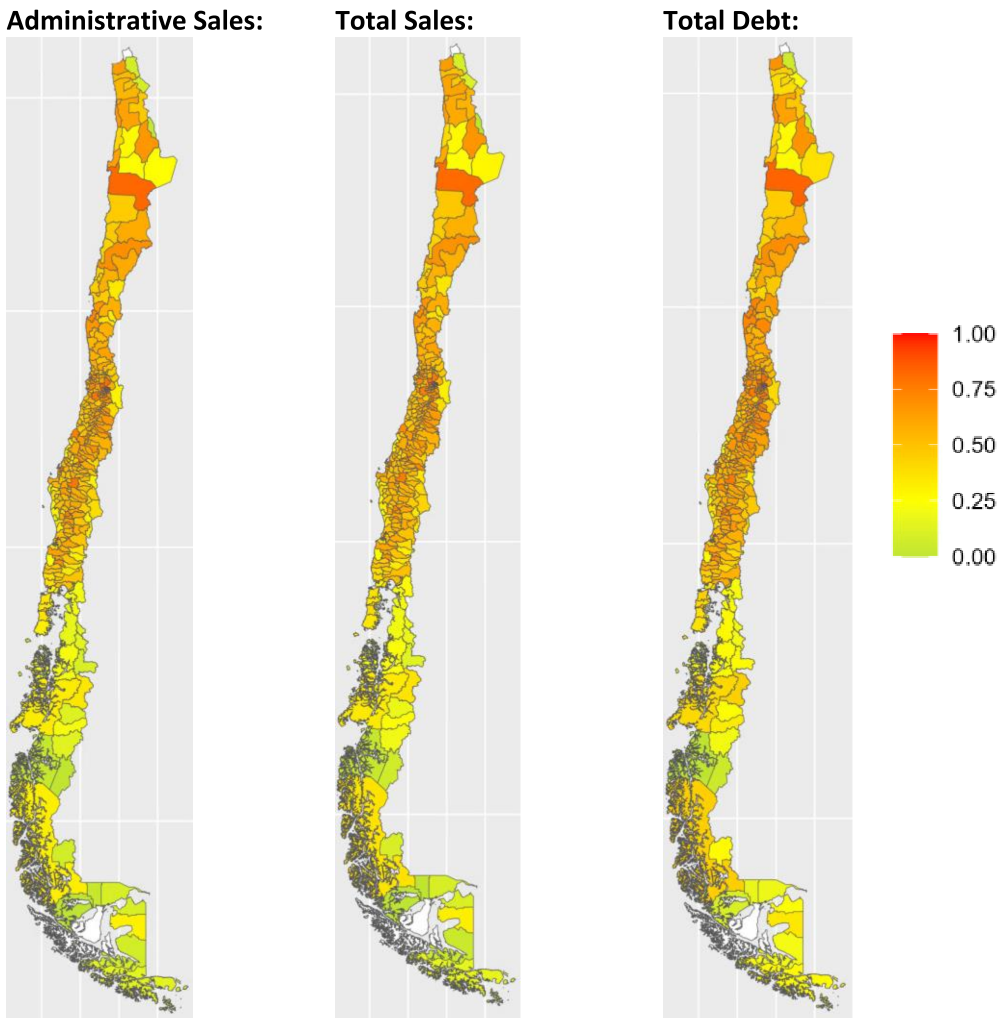


Total Debt:



Source: Central Bank of Chile based on SII (Chilean tax authority) and ARClim data.

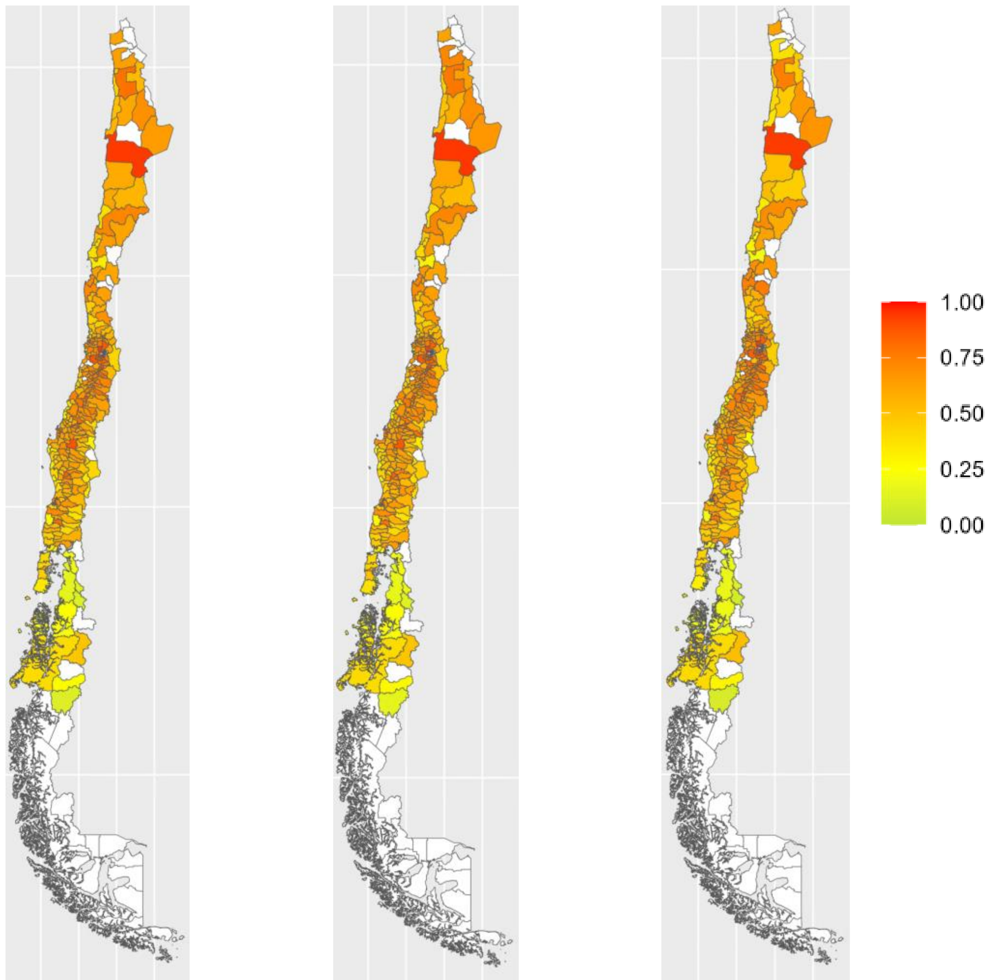
1.2.2 Extreme Heat



Source: Central Bank of Chile based on SII (Chilean tax authority) and ARClim data.

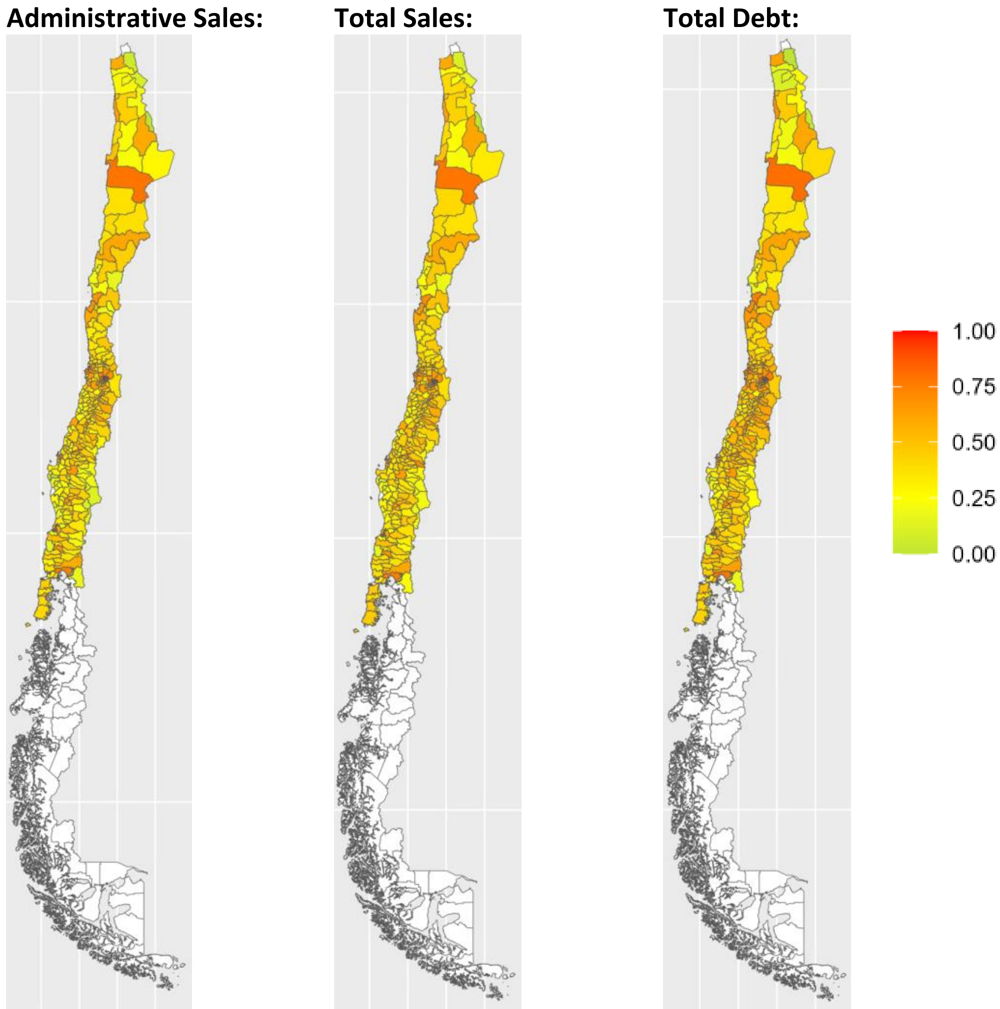
1.2.3 Urban Fires

Administrative Sales: **Total Sales:** **Total Debt:**



Source: Central Bank of Chile based on SII (Chilean tax authority) and ARClim data.

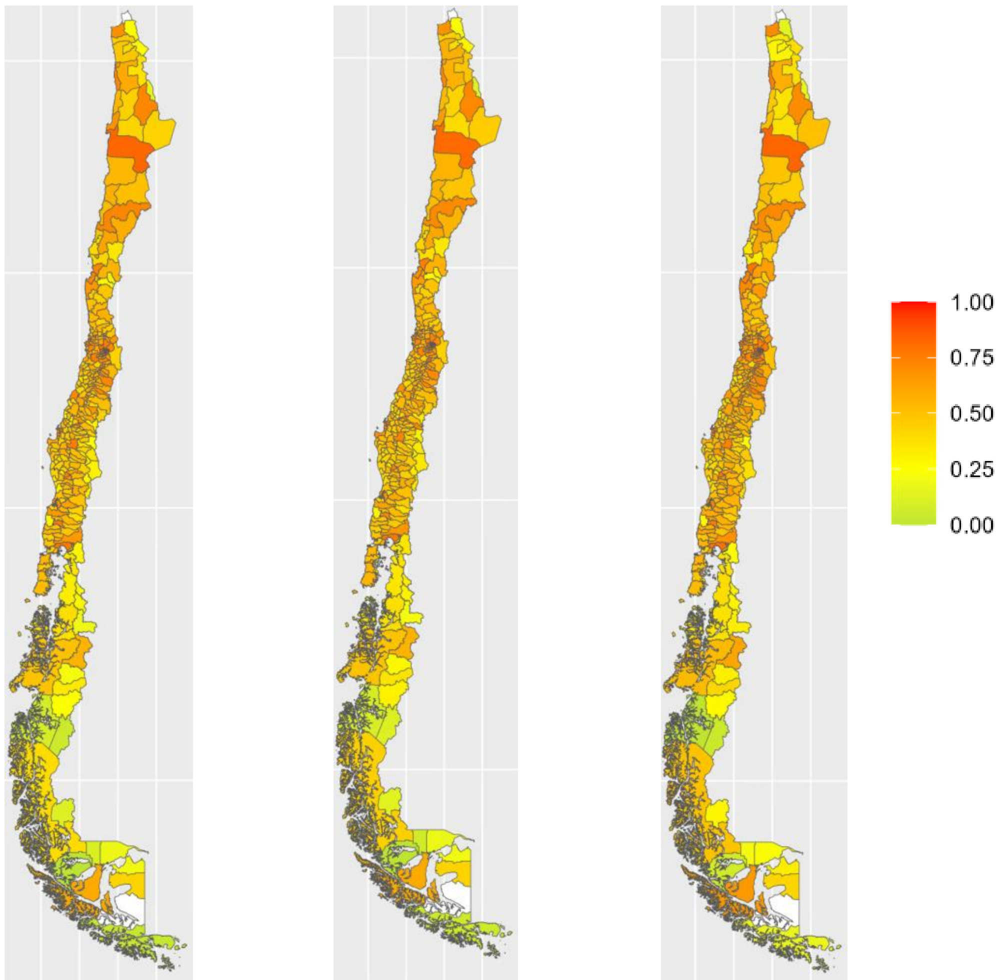
1.2.4 Hydroelectric Generation



Source: Central Bank of Chile based on SII (Chilean tax authority) and ARClim data.

1.2.5 Heat mortality.

Administrative Sales: **Total Sales:** **Total Debt:**



Source: Central Bank of Chile based on SII (Chilean tax authority) and ARClim data.

Figure 2.1

Debt vs Administrative Sales
Sales and debt are highly correlated at the micro-level, such correlation is clearer as sales increase.

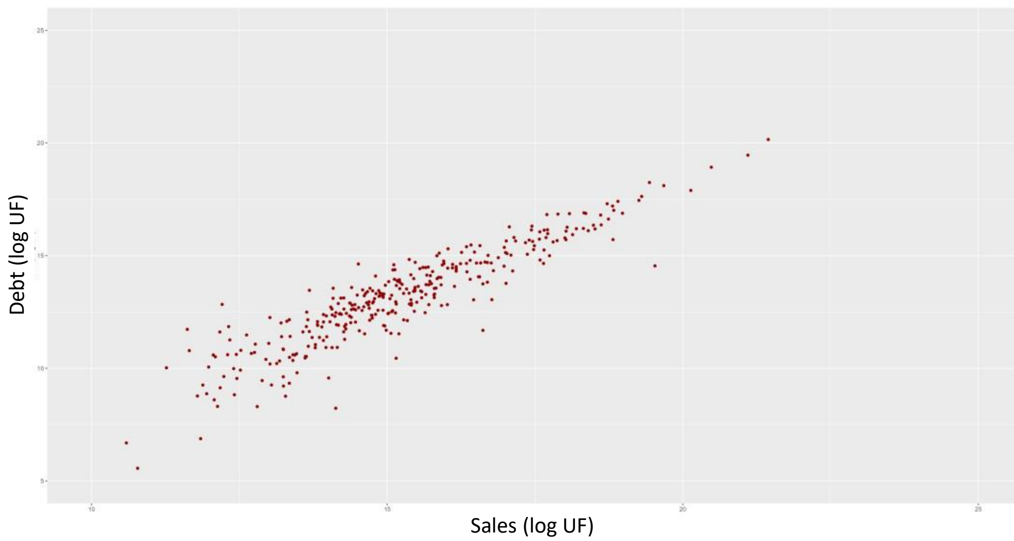


Figure 2.2

Water Safety
Most of the debt and sales are in municipalities where the water safety risk is high.

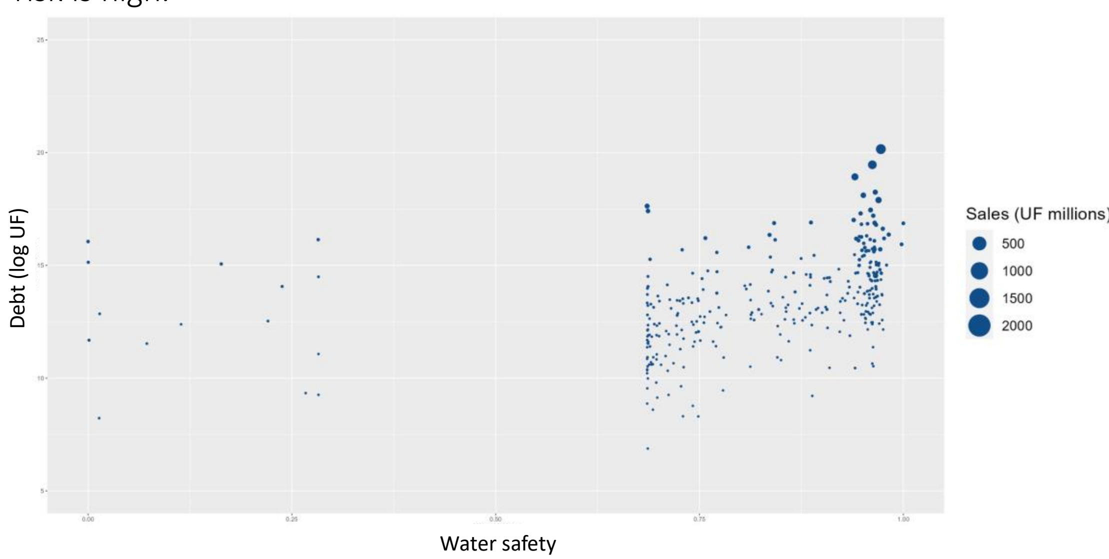


Figure 2.3

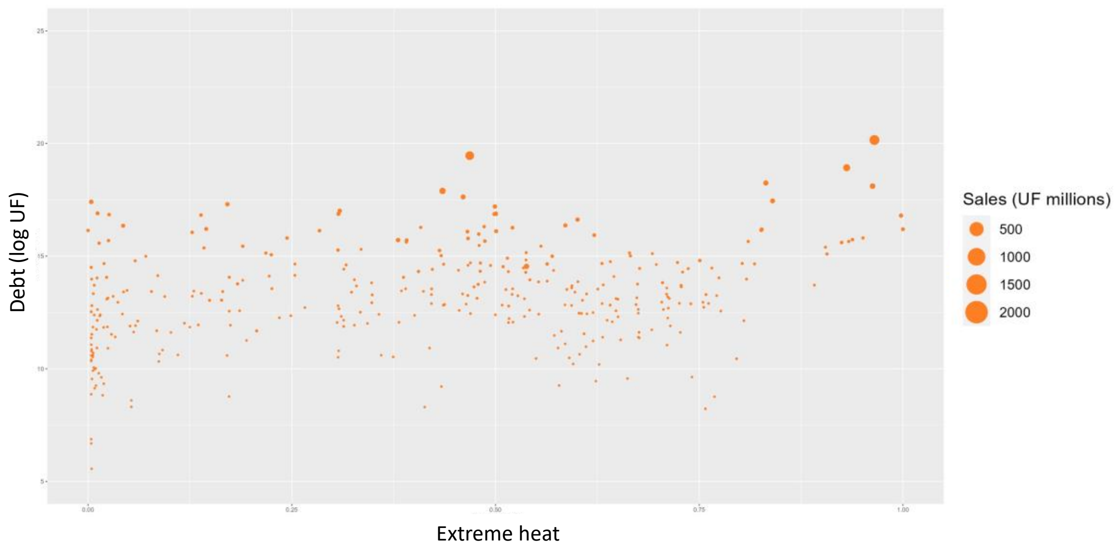


Figure 2.4

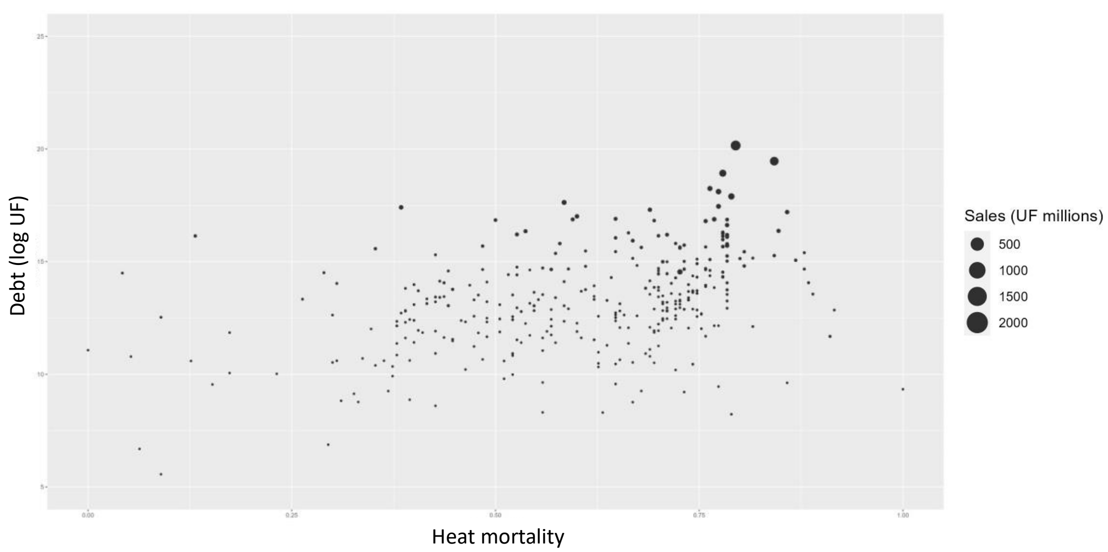


Figure 2.5

Urban Fires
Urban fires have low prevalence as prospecti

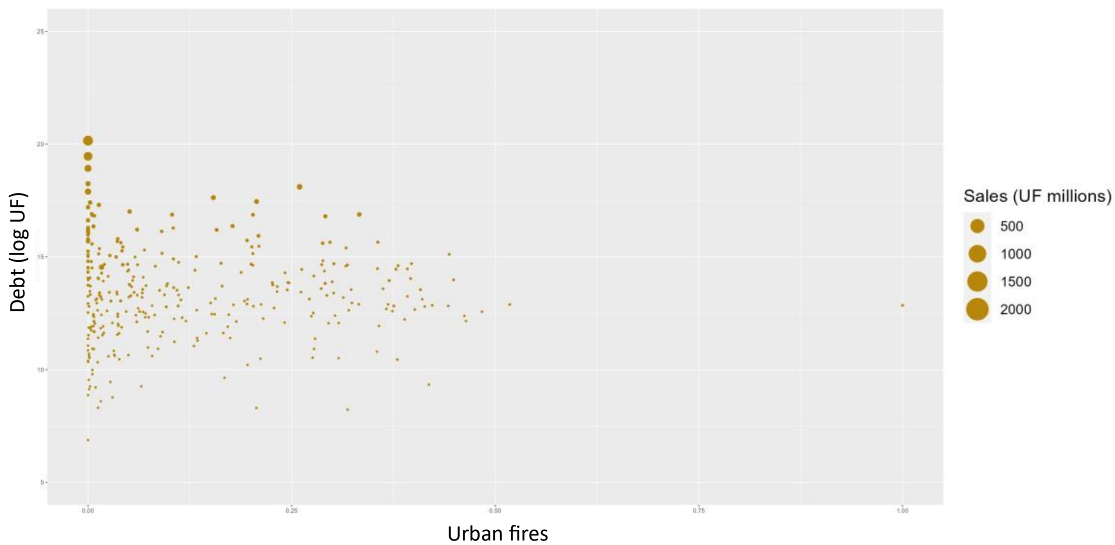


Figure 2.6

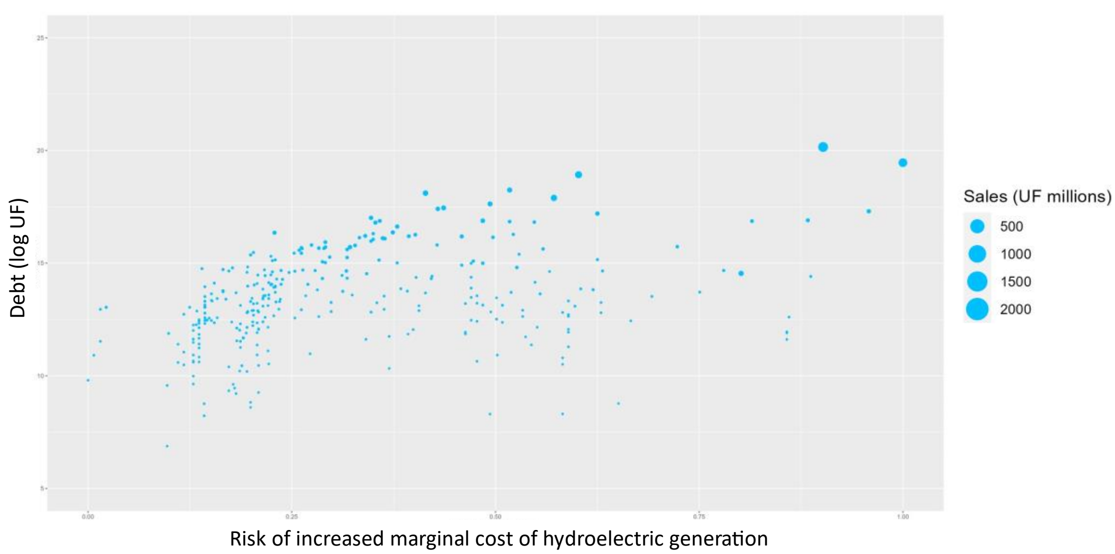


Table 2a – Distribution of debt and sales by physical risk across municipalities using the location of the seller.

Adm. Sales (percent)	Water Safety	Extreme Heat	Urban Fires	Heat Mortality	Hydroelectric Generation
Low risk	8.0	11.7	70.9	6.6	3.4
Medium risk	18.4	42.4	13.5	15.7	19.6
High risk	73.5	46.0	15.6	77.7	77.0

Debt (percent)	Water Safety	Extreme Heat	Urban Fires	Heat Mortality	Hydroelectric Generation
Low risk	7.2	11.6	73.8	6.6	2.2
Medium risk	18.2	34.5	11.5	15.6	15.3
High risk	74.6	53.9	14.8	77.8	82.5

Table 2b – Distribution of debt and sales by physical risk across municipalities using the location of the buyer.

Adm. Sales (percent)	Water Safety	Extreme Heat	Urban Fires	Heat Mortality	Hydroelectric Generation
Low risk	10.6	14.7	70.8	8.7	4.0
Medium risk	16.7	38.2	13.9	15.9	20.1
High risk	72.7	47.1	15.4	75.5	76.0

Debt (percent)	Water Safety	Extreme Heat	Urban Fires	Heat Mortality	Hydroelectric Generation
Low risk	7.1	12.0	76.6	6.4	2.1
Medium risk	16.4	28.4	10.2	14.0	14.7
High risk	76.5	59.6	13.2	79.7	83.2

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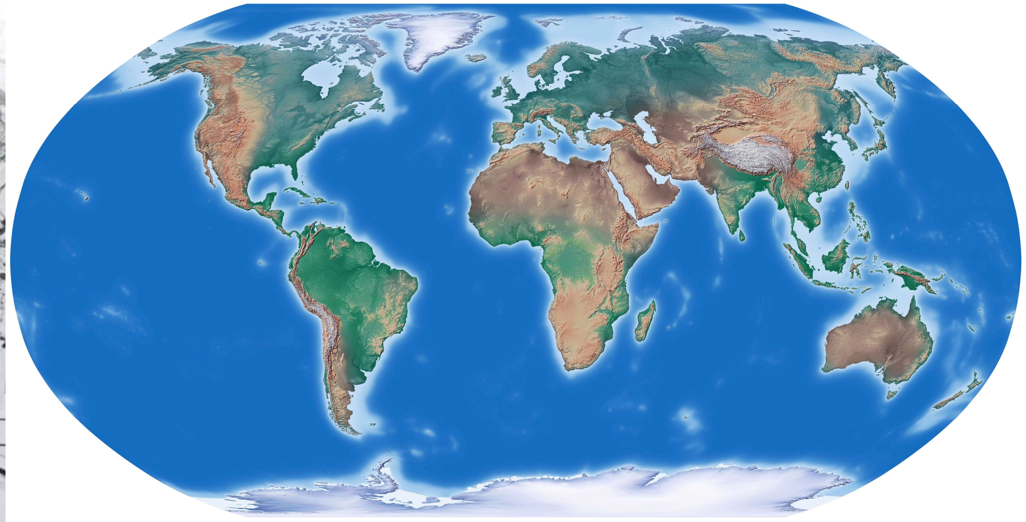
Geolocation Data Challenges for Physical and Financial Risks from Climate Change

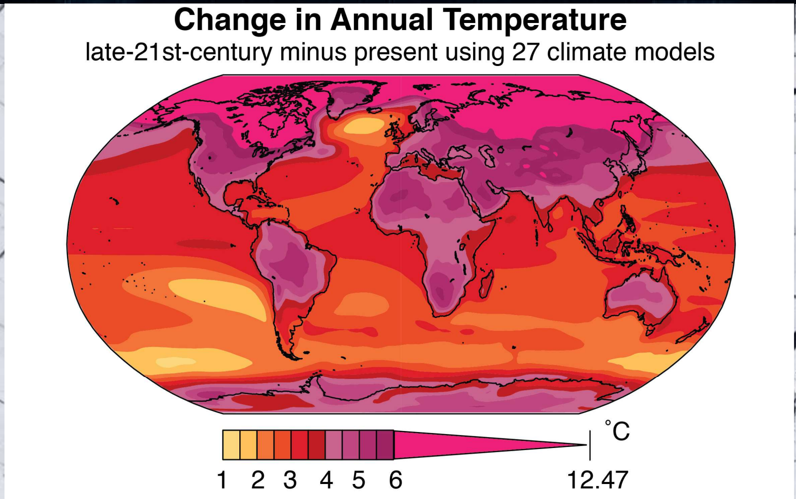
Pablo García Silva (pgarcia.s@uai.cl)
Universidad Adolfo Ibáñez
May 2024 – Izmir

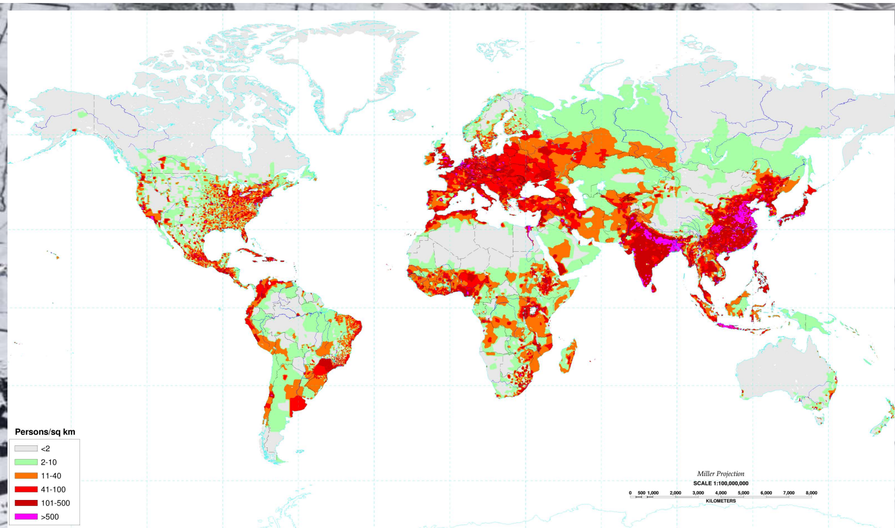
CBRT-IFC Workshop
"Addressing Climate Change Data Needs: The Global Debate and Central Banks' Contribution"

Sovereign states as identified by Gleditsch and Ward (2007). Only countries that are independent today are shown in the map. Current country borders are used across time.

How we economists see our world

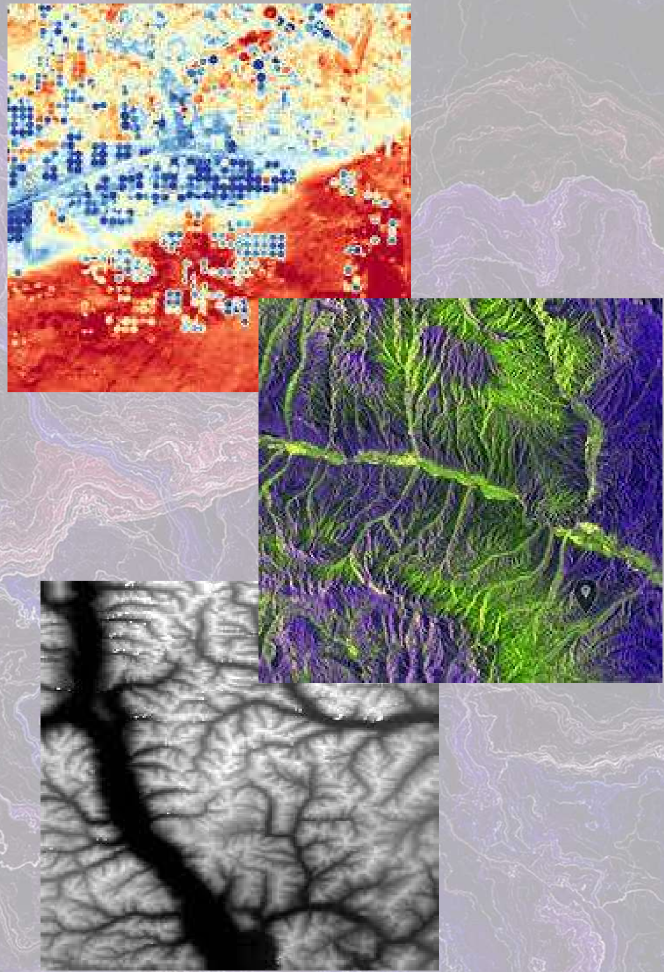


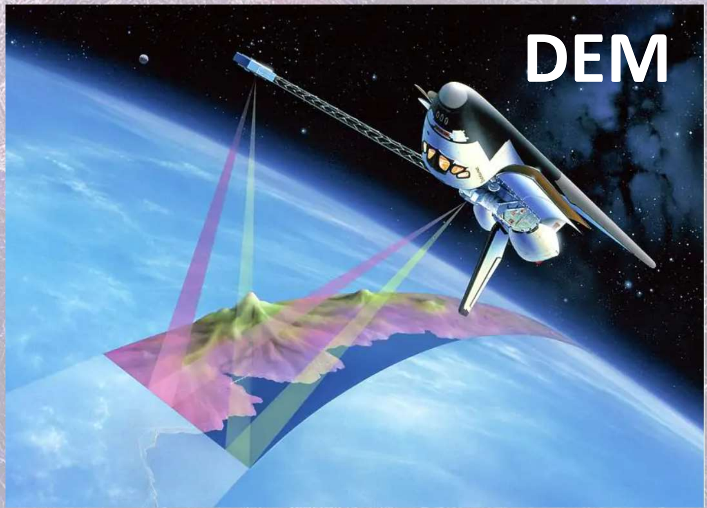




How we should see our world

We can see our world today





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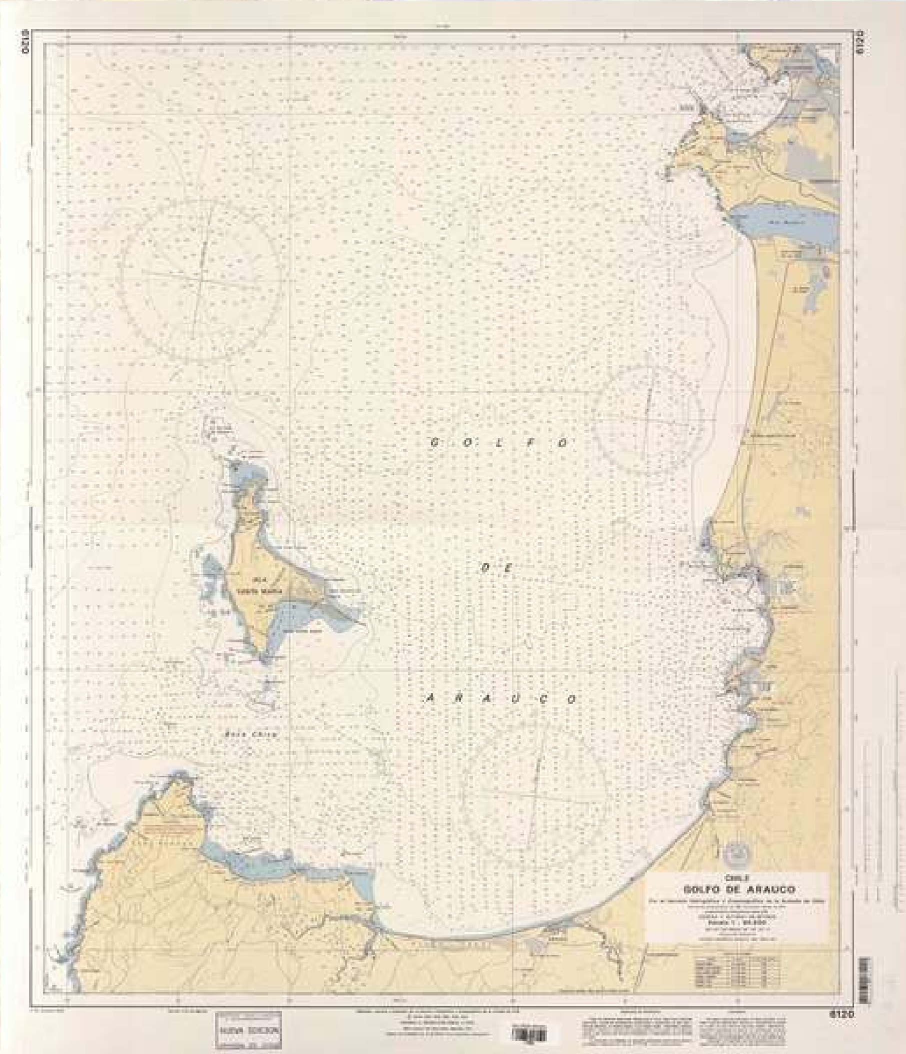

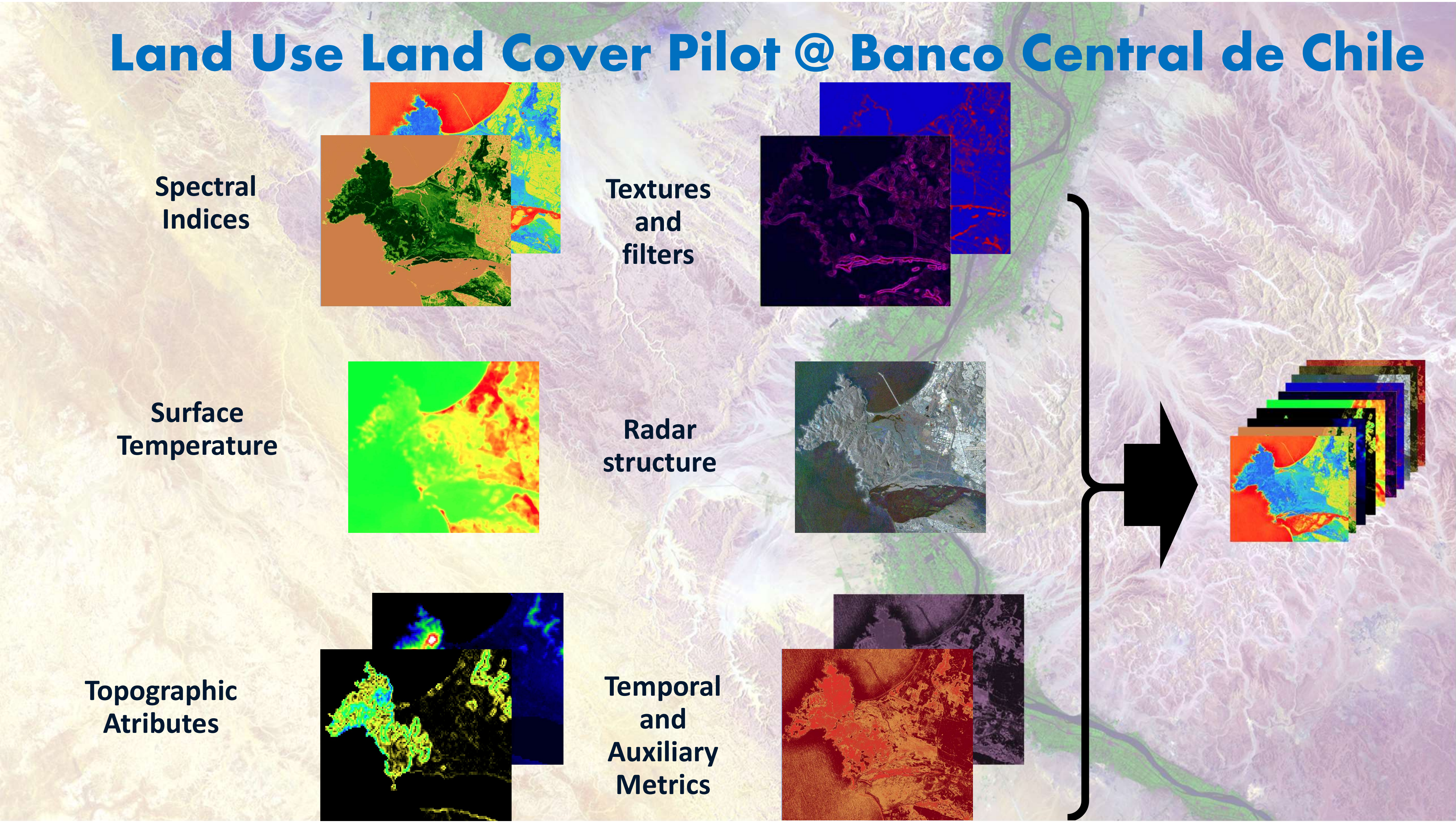
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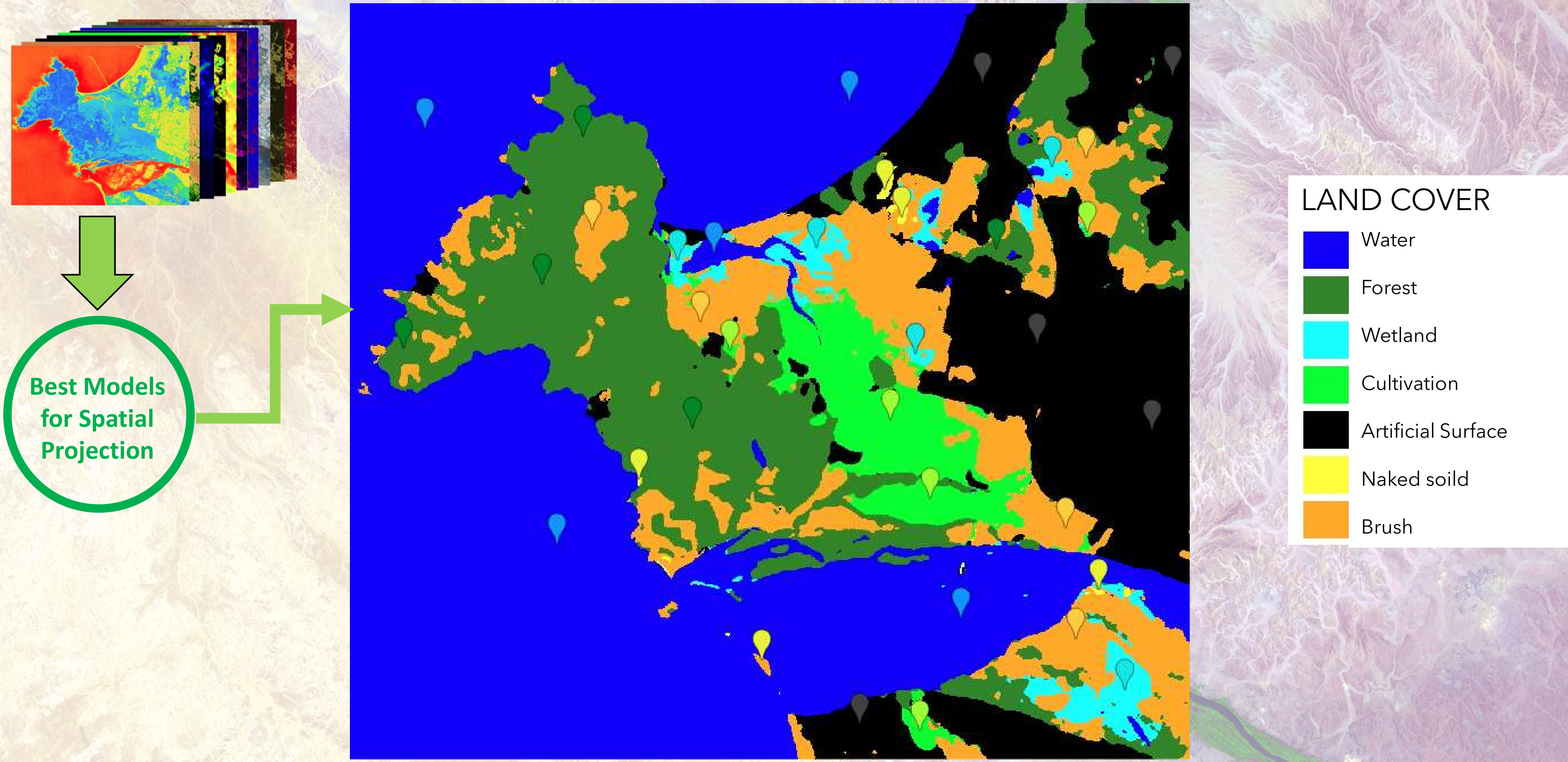
Spectral Indices
Textures and filters
Surface Temperature
Radar structure
Topographic Atributes
Temporal and Auxiliary Metrics

Land Use Land Cover Pilot @ Banco Central de Chile



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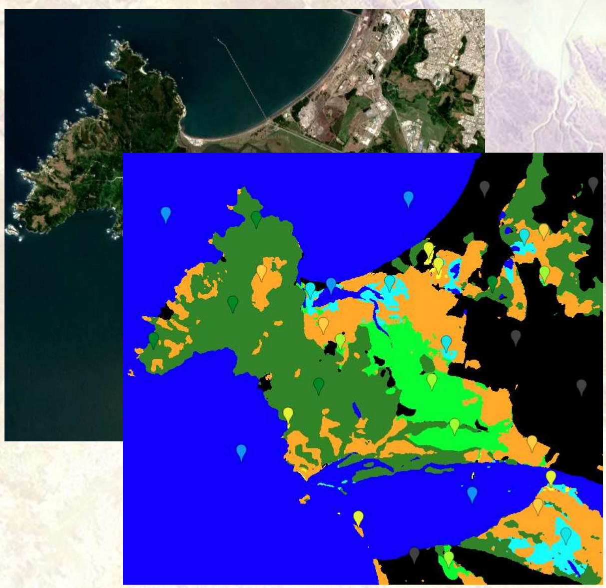
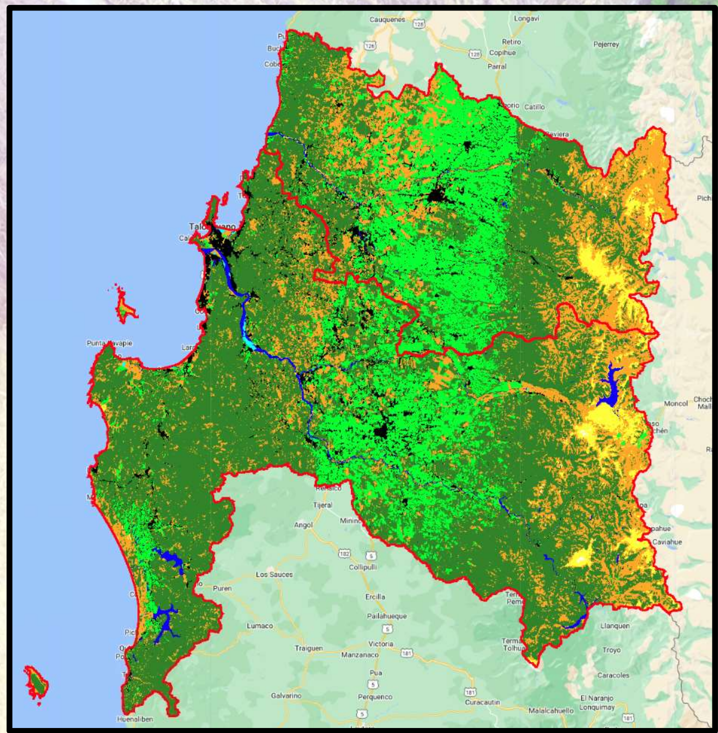
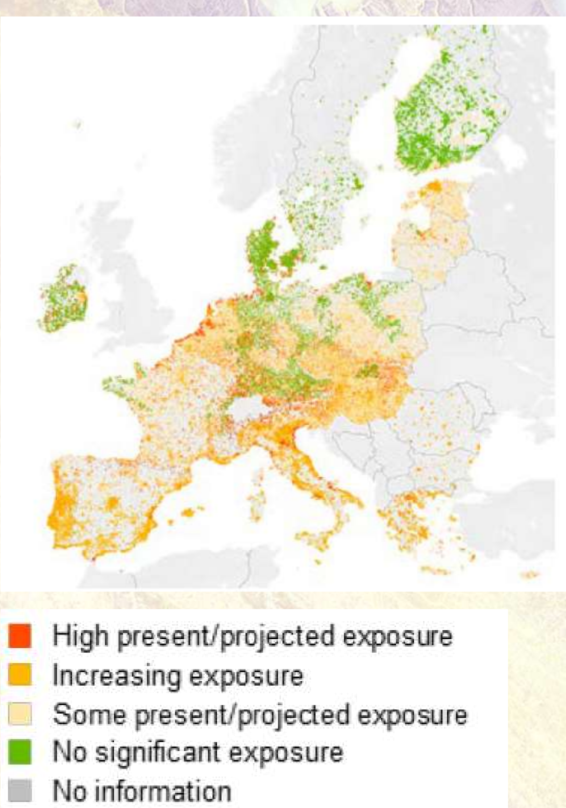




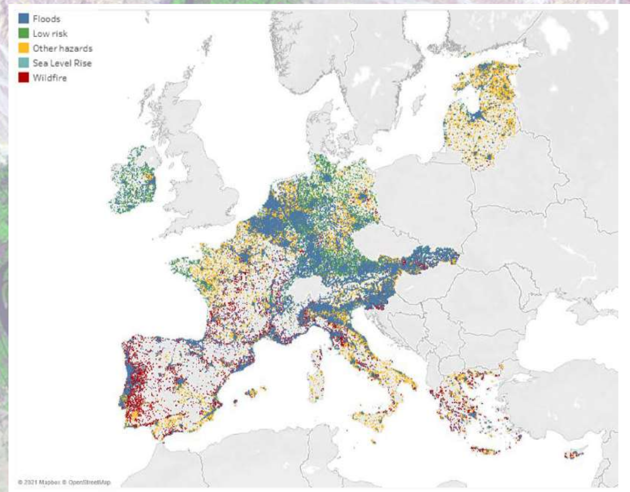
Physical Risk Exposures to Climate Risk

Corporate exposure to physical risk drivers (maximum risk level of each firm)



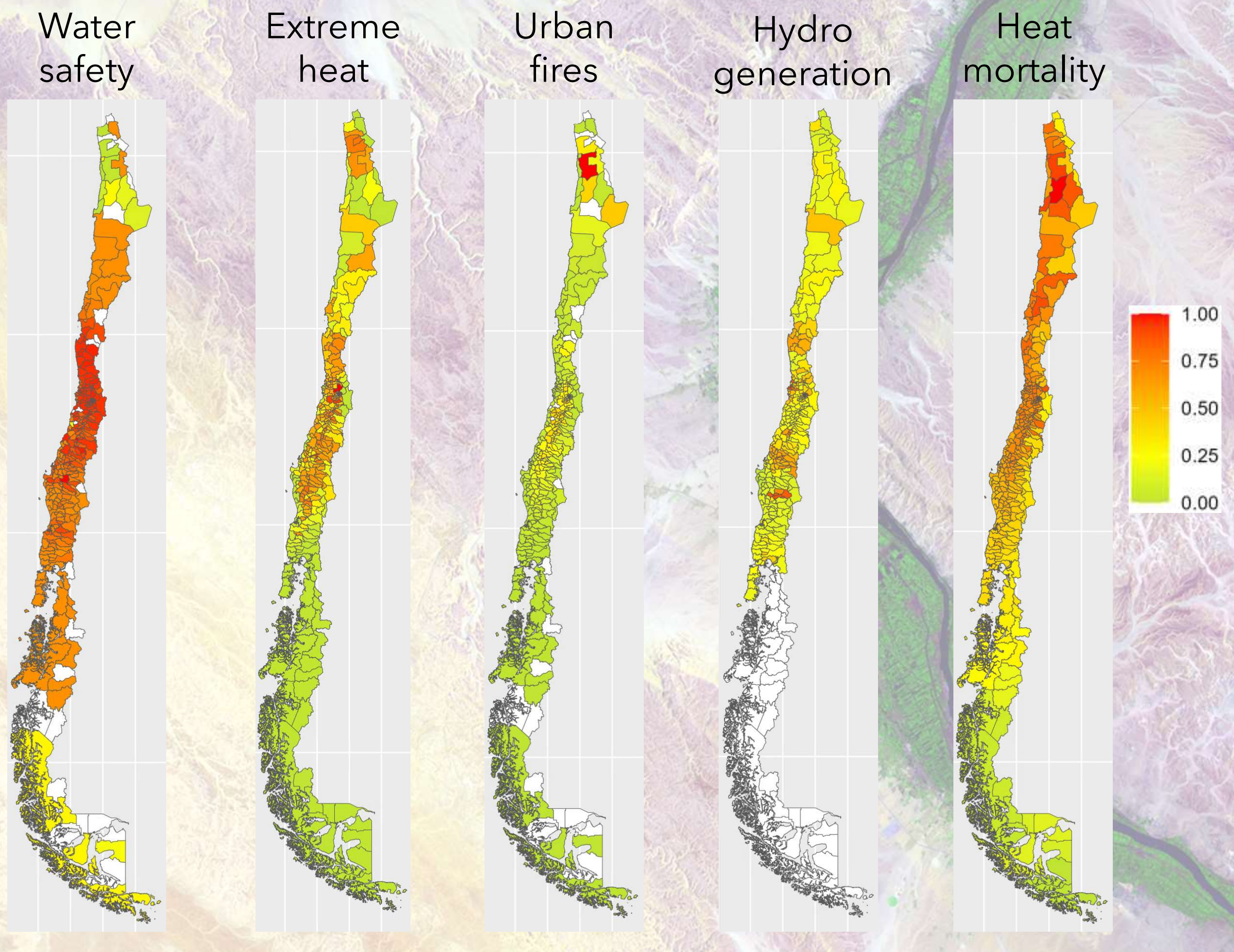
Source: Financial Stability Review. May 2021. European Central Bank

Physical risk: intensity and sources across European regions (maximum risk level of each firm)

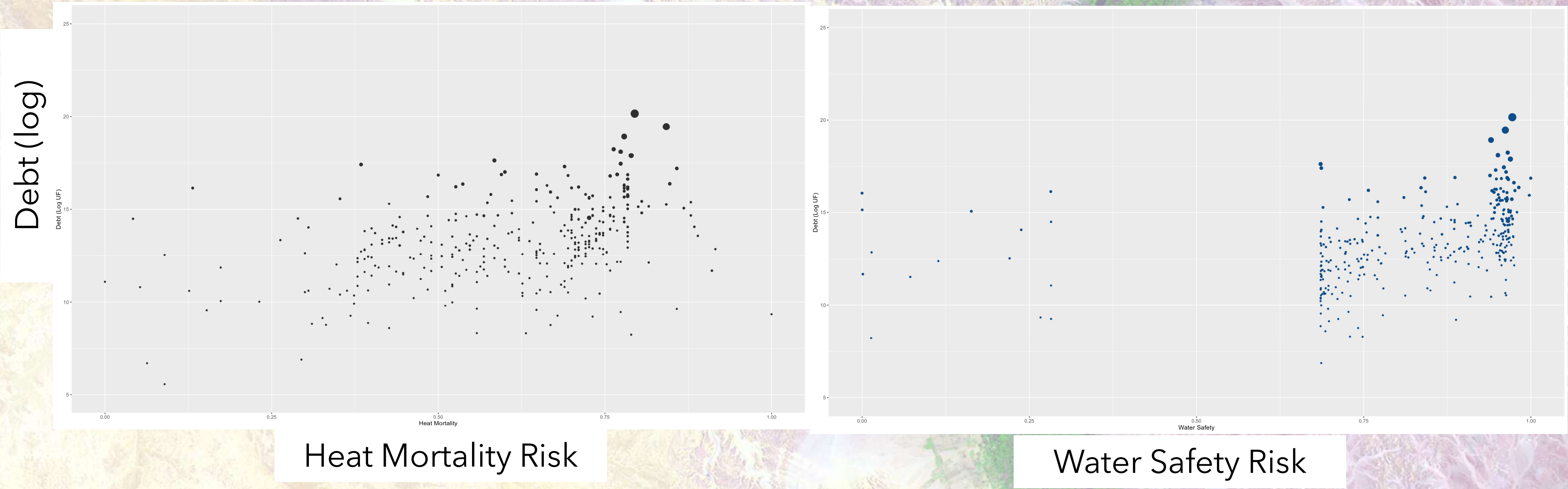


Source: Alogoskoufis et al. 2021

Physical Risk Exposures to Climate Risk



Relevance to Financial Stability



Each dot is a municipality in Chile. Size is proportional to local sales. Heat Mortality and Water Safety Risks are higher in municipalities relatively large and holding more bank assets.

Incoming Challenges for the Community of Central Banks

Statistical areas in central banks will play key role	The international dimension demands a coordinated response	Policy implications will require broader engagement

Statistical areas in central banks will play key role

- More autonomy
- Statistics are less politically contentious at the starting point
- Requires expertise into other social and natural sciences
- Geolocation data gathering will demand ingenuity and innovation

The international dimension demands a coordinated response

- Risks and measurements do not care about political borders
- Global initiatives such as DGI3 need to be disseminated to the global community beyond G20
- BIS/IFC and IMF can be catalysts to these efforts

Policy implications will require broader engagement

- Policy implications go well beyond what can be implemented by traditional monetary/financial policies
- A proper governance in these areas will be critical to preserve the credibility of central Banks´ statistical function

THANK YOU

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