Climate Change and Municipal Bond Ratings

By

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SUBMITTED TO THE DEPARTMENT OF MANAGEMENT IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN MANAGEMENT RESEARCH

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

May 2024

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January 31, 2024

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Submitted to the Department of Management
on January 31, 2024, in partial fulfillment of the
requirements for the degree of
Master of Science in Management Research

Abstract

This paper examines whether climate change risks are incorporated into municipal bond ratings. In particular, I investigate whether municipalities with exposure to sea-level rise have lower bond ratings. Using a sample of rated bond issuances from 2011 to 2020, I document a negative relationship between bond ratings and climate risk for municipalities with exposure to sea-level rise. I also test whether there is a difference in ratings between coastal municipalities and a control group of non-coastal municipalities and find mixed results. My preliminary findings suggest that this risk is at least partially incorporated into bond ratings, however, the magnitude of the effect is small.

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Acknowledgments

I am grateful to Joseph Weber for his guidance. I thank Samuel Anderson, Brian Baik, Tim de Silva, Jacquelyn Gillette, David Kim, Eric So, Rodrigo Verdi, Gabriel Voelcker, Yuting Wang, and Rachel Yoon for the helpful comments and guidance. The views expressed here are those of the author and do not represent the views of any institutions. All errors are my own.

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Chapter 1

Introduction

In this paper, I examine whether climate change risks are incorporated into municipal bond ratings. The municipal bond market offers a unique setting to study climate change risks because municipalities are geographically constrained. While corporations and individuals may relocate to avoid the costs associated with climate change, municipalities cannot avoid or diversify this risk. Thus, municipalities likely to be impacted by climate change will face additional fiscal constraints, thereby increasing their default risk. The municipal bond market makes up $4 trillion (10%) of the bond market. The combination of low liquidity in the market, opaque issuer information environment, and high participation from individual investors (40%) makes credit rating agencies an important information intermediary in this particular market.

The largest three rating agencies (Moody's, S&P, and Fitch) base their municipal debt ratings on the municipality's current fiscal position, ability to meet its obligations, and its current and future economic conditions. Since climate change imposes heterogeneous risks across municipalities, it is important to consider when evaluating future economic conditions. Although rating agencies have acknowledged that climate change could impact municipal finance significantly, the risk is not yet formally incorporated in their rating methodologies.

The measure of climate change risk that I focus on is sea-level rise. Sea levels have risen about 0.20 meters in the past century, and the rate of sea-level rise has increased rapidly in the past few decades.[1] In the short-term, coastal communities have and will continue to

[1] IPCC (2021), The Physical Science Basis: Summary for Policymakers

experience increases in erosion, power outages, and the frequency and severity of flooding and hurricanes. Wellington Management's 2019 white paper uses Terrebonne Parish, LA as an example of how climate change has already impacted some municipality's financing: "*Since 2015, Terrebonne Parish in southern Louisiana has lost 2.5% of its population, while its debt per capita has increased by 34%. One of the parish's islands has lost 98% of its land area... Over 75% of the parish's capital budget is already allocated to climate-related projects, including drainage improvements, relocation of government buildings, and coastal restoration... We expect other communities in the southeastern US to face similar financial pressures and credit deterioration going forward.*"[2] Although most coastal communities have not yet experienced as severe effects, long-term projections predict dire fiscal consequences for municipalities. For example, Shi and Varuzzo (2020) estimate that a 3-foot increase in sea levels in Massachusetts is projected to result in a loss of 1.4% ($104 million) of annual property taxes across all coastal municipalities, and a 6-foot increase is projected to result in a loss of 12.5% ($946 million). These increases are expected to occur within the next 50 to 100 years, depending on how aggressively carbon mitigation is pursued. The timing of the realization of consequences of sea-level rise for a municipality could vary significantly depending on its fiscal position, mitigation planning, and residents' concern levels. Areas with a high amount of residents that are concerned about the potential impact of sea-level rise in their municipality may opt to relocate before more severe consequences are realized. Additionally, corporations may choose to relocate or choose to begin operations elsewhere. Thus, the ex-ante effects of climate change risks may be reflected in a municipality's revenue-generating activities, such as taxes (property, business, sales, etc.) and business-type activities (airports, water, sewer, and utilities, etc.) as well as its expenditure and debt activities (infrastructure and mitigation projects).

This leads to the first question this paper aims to address: Are climate change risks indirectly incorporated into municipal bond credit ratings? The literature relating to climate change risks and financial markets is relatively new, however, findings on whether investors price this risk have been mixed. Ceteris paribus, a municipality on the coastline would be expected to have a higher default risk on its bonds than a non-coastal municipality

[2] Wellington (2019), Muni market climate risk: Hidden perils, untapped opportunities

with similar financial characteristics. I predict that this risk is partially incorporated into municipal bond ratings through an indirect channel. For municipalities already experiencing some of the consequences of climate change, their expenditures and total debt may increase as a result of infrastructure repair or improvement. Additionally, as awareness and concern over the long-term impacts of climate change increases over time, I expect residents to relocate and property values to decline, resulting in decreasing revenues for a municipality. Businesses may reduce their operations as well, resulting in decreasing economic activity for a municipality at high risk. However, since credit rating agencies do not explicitly consider this risk when determining ratings, the extent to which this risk is incorporated into ratings through changes in economic conditions or increasing expenditures relating to infrastructure repair and mitigation projects could be insignificant.

To measure climate risk for a municipality, I follow the approach of Painter (2020) by using Hallegatte, Green, Nicholls, and Corfee-Morlot (2013)'s measure of annual GDP loss resulting from a 40cm sea-level rise. Since the measure is only available for 22 large coastal cities in the US, I extend the treatment group by assigning the same climate risk measure for municipalities within 10km of the 22 cities. My sample includes Moody's, Fitch, and S&P-rated bonds issued between 2011 and 2020. I first test the relationship between climate risk and the average rating (if rated by multiple credit rating agencies) within the treatment group and find a negative and significant relationship between climate risk and credit ratings. I also test this excluding New Orleans, since New Orleans has a substantially higher expected GDP loss than the other large coastal cities. I find a negative and significant coefficient at the 10% level. However, when testing this by credit rating agency, I find a negative and significant coefficient on my measure of climate risk for only Moody's and S&P, and only Moody's-rated bonds when excluding New Orleans from my sample.

Next, I examine if bonds issued by coastal municipalities have lower credit ratings than bonds issued by non-coastal municipalities. Since my treatment sample of bonds issued by municipalities within 10km of the 22 coastal cities primarily consists of the bonds issued by those 22 coastal cities, I test using two treatment groups: (1) the original treatment group of municipalities within 10km of the 22 coastal cities and (2) municipalities within 100km of the 22 coastal cities. I create the control groups by matching municipalities on financial characteristics, demographics, and the number of bonds issued during the sample period. I find a negative and significant coefficient for the climate risk indicator for the test using the second treatment group but an insignificant coefficient for the test using the first treatment group. This result is likely driven by the control group being a poor match to the first treatment group, since there are fewer large cities in non-coastal states. However, my significant finding for the second treatment group could be the result of a power issue since the matched control group was still relatively poor, although better than the first treatment group's matched control.

My paper contributes to the literature that studies the pricing of climate change risks in markets. Bernstein, Gustafson, and Lewis (2019) and Baldauf, Garlappi, and Yannelis (2020) find evidence that property prices in coastal communities vary based on residents' beliefs of the severity of climate change. Painter (2020) studies municipal bond issuance costs and finds evidence that the market does react to climate change risks following the release of the Stern Report in 2006. Credit ratings are an important dimension to study in the municipal bond market in particular because of municipalities' poor information environment. Since both individual investors and lenders rely on ratings for municipal bonds, credit rating agencies' failure to incorporate this risk into ratings could result in sub-optimal investment or lending decisions. Furthermore, since ratings play a role in the cost of debt for municipalities, this could also lead to sub-optimal lending.

My preliminary findings suggest that this risk has begun to be incorporated into municipal bond ratings, although the magnitude of the effect is less than a single notch. However, these findings are limited due to my measure of climate risk. Since the measure of climate risk used was measured for 22 of the treatment municipalities, which are all large cities, assigning the same climate risk measure to smaller, nearby municipalities could bias against results. Larger cities tend to have stronger fiscal positions and greater economic importance, so the financial impact of sea-level rise may not be as severe because of their ability to raise debt at a lower rate and increased likelihood of receiving intergovernmental transfers from the state and federal government. Since my treatment group is disproportionately made up of large cities, it is difficult to create a comparable control group of municipalities because there are fewer large cities with similar financial characteristics in non-coastal states. Because my current measure fails to incorporate all coastline communities, I plan to use OpenStreetMaps to map the distance between municipalities and the coastline to better identify municipalities that are at high risk of sea-level rise.

Another limitation to my results is selection bias. Municipalities with exposure to sea-level rise that have a high cost of debt may choose to not issue bonds. In the future, I could expand my sample of bond issuances to 2000 to 2020, and use the average rating provided between 2011 to 2020 to capture upgrades and downgrades in ratings instead of the rating at issuance. This could potentially mitigate some of the selection issues since the risks of climate change were less apparent during the 2000s. Additionally, since I conduct my tests at the bond issuance-level, this could also weaken my results because large cities tend to issue more bonds. I could mitigate this by testing at the municipality-level, by using an annual average rating of all general obligation bonds outstanding and annual average rating of all revenue bonds outstanding for each municipality as my dependent variable.

In the future, I aim to identify the mechanism that is being captured by the credit rating agencies' methodology that results in lower credit ratings for coastal municipalities. Lower credit ratings for coastal municipalities could be driven by increasing expenditures for projects associated with this risk. Municipalities at high risk may invest in costly mitigation and repair projects to prevent flooding, resulting in a decreased ability to pay off their debts. Another explanation could be residents' (or potential residents') growing awareness and concern over sea-level rise. In the past decade, awareness of climate change has increased significantly. For residents in high-risk areas with frequent flooding and extreme weather, these concerns may be especially salient. Changes in demographics, such as a decrease in the rate of population growth and/or an increasing median age, would influence the economic outlook channel for credit rating assessments. These changes could also result in decreased revenues for the municipality. To address my second hypothesis, I plan to look at changes in municipalities' expenditures, revenues, debt outstanding, and demographics as well as county-level data from the Yale Climate Opinion survey to determine whether the municipality has a high proportion of concerned residents and changes in population and economic activity across the bond ratings of the treatment and control groups, as well as within the treatment group.

Chapter 2

Background

2.0.1 Municipal Financing

Municipalities are financed via taxes on residents and businesses, debt, intergovernmental revenues, and charges for services. To finance infrastructure improvements or investments, municipalities can opt for pay-go capital financing (normally used for small projects) or pay-use capital (debt) financing. Pay-go capital financing includes cash and current assets. These assets may include taxes (property, income, use, excise, utility, tourism, etc.), user charges, capital reserves, and state and federal grants and aid. On the other hand, pay-use financing includes private bank loans and bond financing. About 90% of state and local capital expenditures are financed through debt (Marlowe (2015)). Bank loans can be optimal for small municipalities that cannot afford the costs associated with bond issuance and disclosure, however, loans can be more expensive in the long run.

Because of the higher long-term costs of loans, issuing bonds is ideal for most municipalities. Municipal bonds are exempt from federal tax, and thus, have lower interest rates. The most commonly issued bonds are general obligation (GO) and revenue bonds. GO bonds are paid through the issuer's general tax revenues and are normally used to fund public projects, such as schools, libraries, city halls, etc. Because GO bonds are backed by the issuer's full faith and credit, these bonds tend to have better credit ratings and are thus, cheaper to issue. However, GO bonds require voter approval and are subject to debt limits. On the other hand, revenue bonds are non-guaranteed and tend to be used for public infrastructure with a revenue stream, such as toll roads and bridges, utilities, and hospitals. Because they are secured by the revenue the project generates, they tend to be riskier and more costly. Other types of bonds include private activity bonds, which are bonds issued by municipalities on behalf of a private company, and lease financing.

2.0.2 Municipal Bonds and Credit Ratings

Information Environment

Municipalities are known to have a relatively opaque information environment relative to corporations. The municipal market differs from the equity market in that the process of buying and selling is a bilateral negotiation, as opposed to competitive market-making with anonymous trading. Municipal bond dealers have better information about order flow than investors, and are thus, informationally advantaged. Furthermore, the dealer may also be the underwriter of the bond itself. Because of this information advantage that the dealer has, individual investors are at a strong disadvantage due to higher information acquisition costs and counter-party search costs. Due to the poor information environment, investors in municipal bonds may rely more heavily on credit rating agencies for risk assessments than in other markets.

In 2009, the Municipal Securities Rulemaking Board (MSRB) implemented the Electronic Municipal Market Access (EMMA), a central electronic repository for municipal disclosure filings, making financial information more easily accessible. Cuny (2018) finds that following EMMA, the small trade premium declined, implying a decrease in information processing costs for individual investors. This effect was stronger for municipalities with more opaque information environments previously. Despite improvements in the information environment, the SEC notes that there still are issues surrounding accessibility and timeliness of municipalities' financial information and bond issuance filings (SEC (2012)). Following the financial crisis, investors' faith in credit rating agencies declined. However, this did not appear to be the case for the municipal market; Cornaggia, Cornaggia, and Israelsen (2018) uses Moody's 2010 re-calibration and finds evidence that municipal bond market investors still rely on ratings for credit risk assessments and Cornaggia, Hund, and Nguyen (2020) finds that the municipal market did not react to Ambac and MBIA's bankruptcy (the largest municipal bond insurers) until ratings were downgraded.

Ratings Factors

Although the largest three credit rating agencies use different methodologies, they consider and weigh the same over-arching factors. The primary factors and weightings are economic conditions (30%), revenues and expenditures (30%), long-term obligations (20%), and operating performance (20%) (Moody's (2020), Fitch (2020), S&P (2013)).

Economic conditions are measured using demographics-related statistics, such as population changes, median family income, income per capita, etc. This factor aims to measure future revenue-generating ability. Revenues and expenditures are used to evaluate the municipal's ability to meet its existing obligation and budgetary flexibility. Long-term obligations are used to evaluate the future cost of debt and tax base. Operating performance evaluates the municipal's budgeting accuracy and its ability to plan, monitor, and manage its finances. Although not explicitly stated as a factor in ratings, Henke and Maher (2016) observes a negative relationship between the number of days from fiscal year-end to the CAFR release date and bond ratings.

There are also qualitative factors considered to obtain the final rating. These qualitative considerations may include the presence of a consistent major employer, the degree of diversification within its economy, population changes, and county unemployment rates.

Other factors may manifest themselves in credit ratings indirectly. Butler, Fauver, and Mortal (2009) examines the relationship between state corruption levels and municipal financing outcomes. They find that corruption and ratings have a negative relationship and that corruption and yields have a positive relationship. Cornaggia, Hund, Nguyen, and Ye (2021) examines how opioid abuse can impact municipal financing by decreasing capital supply and find that high-abuse regions have lower credit ratings and fewer bond issuances. Additionally, they find that successful implementation of anti-opioid legislation can mitigate the adverse effects on financing.

2.0.3 Climate Risk

This stream of literature has developed as a result of growing awareness of climate change and its potential economic impacts. Climate change risk levels vary geographically. Relative to large corporations, municipalities face significantly higher climate risk. Large corporations may have operations or offices in high climate risk areas, but their locations are geographically diversified and could potentially be relocated. On the other hand, municipalities cannot relocate and diversify this risk. Thus, municipalities offer a unique setting for studying the economic implications of climate change risk.

Climate change has not only resulted in global warming, but also an increase in the quantity and severity of natural disasters, droughts, and wildfires. Here I focus on sea-level rise, an effect of global warming that may not be a significant issue in the short-term, but in the long-term, could result in high infrastructure repair and mitigation costs for municipalities.

There are many different avenues in which climate change can impact a municipality's finances. Areas at high risk for natural disasters could become too costly for residents and businesses to live and operate in due to high property and casualty premiums. This decline in population would result in a decline in tax revenue (property, sales, business, etc.). Meanwhile, the municipality would find itself in a conundrum - significant capital expenditures would be required to mitigate climate risk, but the decline in revenues would make obtaining debt or issuing bonds significantly more costly due to the increased default risk. Raising taxes may drive more residents and businesses out of the area. Property insurers have already begun to leave certain markets (California, Texas, and Florida) that have had catastrophic natural disasters in recent years.

Credit Risk Agencies

Credit risk agencies have acknowledged the need to incorporate climate change risk into their ratings. In 2017, Moody's warned municipalities in coastal areas that failure to prepare for climate change risks would result in ratings downgrades (Bloomberg (2017)). Although none of the largest three credit rating agencies have begun to explicitly incorporate climate risk into ratings, they contend that they still consider this risk. S&P reviewed its corporate ratings at issuances and updates from 2015 to 2017 and found that 1.2% of its rating changes resulted primarily because of climate and environmental factors (only 40% of those were downgrades).[1] Fitch stated that they believed environmental factors was relevant for only 1.25% of rating decisions related to infrastructure and public finance, and that climate change was relevant for about one-third of that sub-sample.[2]

Some have begun taking action towards quantifying this risk. In 2019, Moody's acquired a climate data firm (Flavelle (2019)). However, only 2 of the 45 global financial institutions surveyed by Oliver Wyman in 2019 incorporate climate change risk in their credit risk assessments - one-third do not consider this risk at all.[3]

The hesitance to formally quantify and incorporate this risk could be due to a number of reasons:

1. Credit risk agencies do not believe that climate risk is a material risk. Given that S&P and Fitch's retroactive reviews resulted in very few changes due to climate risk specifically, this could be a plausible explanation.

2. Insurance and federal aid is expected to cover a substantial portion of damages and rebuilding costs in severe cases. Many assume that the costs associated with natural disaster-related damages will be covered by the Federal Emergency Management Agency (FEMA); however, this funding is not guaranteed. If the risks were known and the municipality failed to implement mitigation strategies then the state and municipality may have to cover the damages (S&P (2019)). However, this poses a large challenge towards estimating the financial impact of climate risk for a municipality. Federal programs under FEMA like the National Flood Insurance Program can cover 75-90% of the rebuilding costs, thus creating credit distortions (Brookings (2017)).

3. Credit risk agencies do not believe this risk is estimable. This is also a likely explanation since there is uncertainty surrounding whether and to what extent FEMA will provide

[1] S&P Global (2017), How environmental and climate risks and opportunities factor into global corporate ratings

[2] Fitch (2019), Introducing ESG relevance scores for public finance infrastructure

[3] Oliver Wyman (2019), Climate change: Managing a new financial risk

disaster relief funding, the effectiveness of mitigation initiatives taken by municipalities, and the aggressiveness and effectiveness to which carbon mitigation initiatives will be pursued in the next few decades.

4. Credit risk agencies may not have a strong incentive to issue lower ratings because of the issuer-pay structure (Beatty, Gillette, Petacchi, and Weber (2019), Jiang, Harris Stanford, and Xie (2012)).

Municipalities

The growing literature relating to municipalities and climate risk has focused on whether climate risk is priced into municipal bond yields. Painter (2020) examines whether municipal bond yields are affected by climate risk exposure. He finds that climate risk increases the cost of borrowing, and that this relationship is stronger for long-term bonds (more than 25 years until maturity) and when credit ratings are low.

Goldsmith-Pinkham, Gustafson, Lewis, and Schwert (2021) look at bond issuances at the school district-level and find that municipal bond investors expect a 1 standard deviation increase in sea-level rise exposure to correspond with a reduction of 2-5% in present value or an increase of 1-3% in the volatility of the local government's cash flows supporting debt repayment. This finding implies a significantly larger economic impact than the measure used by Painter (2020), which uses Hallegatte et al. (2013)'s measure of annual GDP loss resulting from a 40cm sea-level rise.

Tran and Uzmanoglu (2021) examine whether credit rating agencies include climate risk as a factor in their rating models using annual general obligation bond ratings from 2004 to 2018 for 20 of the 22 cities in Hallegatte et al. (2013) and find insignificant results. However, the results could have been driven by (1) the size and economic importance of the municipalities included in their analysis, (2) the sample period, and (3) not accounting for Moody's and Fitch's re-calibration in 2010. The sample includes only large municipalities, which tend to have stronger fiscal positions and are able to allocate resources towards mitigation projects. Moody's has stated that smaller municipalities are at greater risk to have their ratings downgraded due to climate change risks (Bloomberg (2017)). Furthermore, FEMA may allocate more of its funding to larger cities in the event of disaster due to their relative economic importance. The sample period ending in 2018 may have also been too early to realize some of the increasing expenditures and declining revenues municipalities are facing as a result of climate change risk. As the risk becomes more apparent (due to visible natural disasters, extreme temperatures, flooding, etc.), the more likely residents and municipalities will take a course of action. For larger cities, significant changes in demographics may take a much longer period of time to realize. Furthermore, 2018 and onwards is around the time that rating agencies began to issue reports on climate change risks for municipalities and signal increasing scrutiny of this risk. Lastly, not accounting for Moody's and Fitch's ratings re-calibration in 2010 may have biased their results, since the re-calibration resulted in a 0 to 3 notch improvement in ratings, independent of issuer fundamentals.

Much of the prior literature in this area has focused on the impacts of sea-level rise induced by climate change, and whether investors acknowledge this risk. Overall, there seems to be some evidence that investors and underwriters do price this risk, but to the extent that they are properly pricing this risk is still unknown. A limitation to these studies is that they focus on the bond's fundamentals at the time of issuance, and do not consider the secondary market or ratings upgrades/downgrades. However, it would be difficult to isolate trading activity driven by new information related to climate change risks because the municipal market is relatively illiquid.

Another limitation of these studies is the sample of impacted municipalities. Tran and Uzmanoglu (2021) and Painter (2020) use Hallegatte et al. (2013)'s measure for the impact of sea-level rise on municipalities, which includes only the largest coastal cities. Although Painter (2020) studies issuances at the county-level, only the counties in which those large coastal cities are in are assigned a non-zero climate risk measure. The coastline counties that do not have a large city within them are likely to suffer the most economic consequences from climate change risk due to their relatively weaker fiscal conditions.

Other studies have examined the ex-ante and ex-post impact of climate change-related events on municipal finances. Liao and Kousky (2020) examines how wildfires in California impacts revenues and expenditures in municipalities and find that both increase following the event. In particular, both sales and property taxes are increased, and spending on infrastructure improvement and preparedness increases significantly. Shi and Varuzzo (2020) examines the potential impacts of sea-level rise for coastal municipalities in Massachusetts. They estimate a 3-foot SLR would result in a decline of 1.4% of property taxes collected, and that a 6-foot SLR would result in a 12.5% decline. Thus, the short-term risk for many municipalities is not high, but in the long run, losses in revenue increase exponentially.

Bolstad, Frank, Gesick, and Victor (2020) examines the differences in climate risk disclosures by publicly traded firms and municipalities and find that 60% of the 3,000 largest firms discuss climate change in their 2020 10-K filings, while 10.5% of revenue bonds and 3.8% of general obligation bonds discuss climate change in their issuance filings.

Chapter 3

Hypothesis development

I aim to study whether climate change risks are incorporated in municipalities' credit ratings. Although the largest three credit rating agencies have stated that they are not explicitly incorporating this risk, climate change risks may be incorporated into ratings through an indirect channel. When rating municipal debt, they may consider factors such as the issuer's current fiscal position and its ability to meet its obligations, as well as its current and future economic conditions. Even if climate change events may take a long time to realize, the ex-ante effects of it may be reflected in the municipality's revenue-generating and expenditure activities and its current and projected economic conditions.

With respect to its economic condition and projected revenues, climate change risks may be reflected in population and demographics changes. As residents or prospective residents weigh the potential costs and future value of their real estate and property alongside climate change risks, residents may relocate, and demand from prospective residents may decline. This would lead to declines in real estate and property values, automobile licenses, and sales due to lower demand to reside in the region. Furthermore, businesses may opt to move their operations elsewhere or not consider the location for their operations, leading to a decline in new business licenses and taxes collected. Additionally, industries reliant on natural resources such as fishing, tourism, logging, etc. will be negatively impacted, increasing unemployment rates. Since rating agencies consider factors like the population's median age, education levels, and unemployment rates, changes in these may partially reflect expectations of climate change risk. Although a municipality could increase its tax rates to recuperate some of the losses, it runs the risk of driving more residents and businesses to relocate.

Expenditures and debt could also increase as a municipality may try to mitigate these risks through infrastructure improvement, public safety, and community development projects or more insurance coverage. For example, Miami Beach issued $400 million in bonds in 2017, and about half of that is intended to be used to raise roads and seawalls and improve current drainage systems.[1]

I test the following hypothesis to confirm that credit ratings incorporate at least some of the risks associated with exposure to sea-level rise.

H1: Exposure to sea-level rise has a negative impact on a municipality's credit ratings.

I plan to examine the mechanism that is causing the difference in ratings between high climate risk communities and low climate risk communities since climate change risk is not a factor that credit rating agencies incorporate into ratings directly. There are two main channels in which climate change could be indirectly incorporated into ratings: (1) increasing expenditures and debt outstanding, and (2) decreasing revenues and worse economic outlook.

One potential explanation could be that municipalities at high risk may have higher expenditures and debt outstanding associated with mitigation and infrastructure repair. Investing in mitigation projects may be seen as a positive to credit rating agencies, since Moody's stated that municipalities that did not could have their bonds downgraded in the future. However, this does not appear to be implemented in their current rating methodology, and thus, may result in lower ratings because of the increase in total debt outstanding and expenditures.

H2a: The difference in bond ratings between high climate risk municipalities and low climate risk municipalities is driven by increasing expenditures (investments in mitigation and infrastructure repair projects).

Another potential explanation could be through the revenue and economic outlook channels. In the past decade, awareness and concerns of climate change risks have increased significantly. Choi, Gao, and Jiang (2020) finds that when people experience abnormally high temperatures, Google searches related to global warming increase and stock returns of

[1] S&P Global (2021), Climate change poses new threat to US cities' long-term creditworthiness

firms in carbon-intensive industries decline. Similarly, when a natural disaster occurs in a nearby area, this may also increase residents' attention towards the risks of climate change in their own municipality. Bernstein et al. (2019) and Baldauf et al. (2020) find that coastal home prices in neighborhoods vary depending on agents' beliefs of the existence and severity of climate change. Thus, in regions where there are a high proportion of climate change believers, they observe a discount in property values. In regions that have faced severe weather events and natural disasters and nearby regions, the salience of these events is likely higher for residents.

Emigration from coastal communities would result in a negative impact on both the revenues (taxes) collected by the municipality and its economic outlook. Economic outlook is evaluated based on changes in demographics of the municipality - if the rate of population growth or median age declines, this may indicate a worsened economic outlook. I expect municipalities with a high proportion of residents that believe climate change will directly impact their lives to have decreasing population growth rates, decreasing income per capita, increasing median age, and thus, lower credit ratings. For municipalities with a low proportion of residents concerned with climate change, I expect their credit ratings to be higher.

H2b: The difference in bond ratings between high climate risk municipalities and low climate risk municipalities is driven by decreasing revenues and a worse economic outlook.

Both of the two channels could hold simultaneously, however, investments that mitigate climate change-related risks may be able to offset emigration and decreases in bond ratings. Thus, I may also examine whether there are differences in ratings within the municipalities with exposure to sea level rise between those that pursue mitigation-related projects and those that do not.

Chapter 4

Data

I use municipal bond issuance and ratings (Moody's, S&P, and Fitch) data from Mergent Municipal. To avoid the impact of both the financial crisis and Moody's and Fitch rating scale re-calibration in 2010, I restrict my sample to issuances between 2011 to 2020. I convert bond ratings to a numerical scale ranging from 1 to 21, where 21 represents the highest rating (AAA). For bonds rated by multiple credit rating agencies, I take the average of the ratings. I consolidate offerings with multiple CUSIPs and use the latest maturity date to measure the term of the offering. My final sample results in 44,420 observations of rated municipal bond issuances. Of the 44,420 bond issuances, 46.6% (20,707) were rated by Moody's, 74.4% (33,060) were rated by S&P, and 4.9$ (2,197) were raated by Fitch. I use the Google Maps API to obtain each issuer's municipality, county, and geographic coordinates to map the Mergent Municipal data to the municipal finance data from Willamette University, US Census data, and the county-level survey data from Yale Climate Opinions.

For my measure of climate risk, I follow the approach of Painter (2020) by using Hallegatte et al. (2013)'s measure of expected annual loss as a % of GDP for a 40cm increase in sea levels within 50 years. For example, a $ClimateRisk$ of 1.479 for New Orleans, LA, would indicate a 1.479% annual loss in GDP for a 40cm increase in sea levels. To increase the size of the treatment group (which includes 22 large cities), I assign the same climate risk score to municipalities within 10km of the 22 coastal cities. The true expected annual loss scaled by GDP for these additional municipalities is likely to be higher than the ones for the original 22 cities because of their lower economic activity, so this may bias my results downwards.

I calculate the distance between municipalities and the original treatment municipalities by calculating the Haversine distance between the geographic coordinates. For all other municipalities, I assign a climate risk score of 0. Table 1 presents the cities and their respective climate risk measures, as well as the number of additional municipalities within 10km and 100km of the original 22 coastal cities.

I plan to use financial information of the municipalities to measure changes in their expenditures related to infrastructure and mitigation and revenues, demographics information such as changes in population and median age from the US census, GIS data from OpenStreetMaps to measure a municipality's distance from a coastline, as well as survey data at the county-level from Yale Climate Opinions to pinpoint the mechanism driving differences in ratings between the treatment and control groups.

Table 2 presents the descriptive statistics for the sample of bond ratings at the time of issuance. The average rating in the sample is 18.42, which corresponds to a rating between Aa3/AA- and Aa2/AA. The average total offering amount is \$23.93 million, however, the standard deviation is \$59.46 million. For municipalities with $ClimateRisk > 0$, the average total offering amount is \$57 million, while for municipalities with $ClimateRisk = 0$, the average is \$20.83 million. Since the subset of municipalities with $ClimateRisk > 0$ includes several large cities, this explains why there is significant variation in the total offering amount within the sample.

Chapter 5

Research design and results

I first test whether credit ratings vary within the treatment group. I estimate the following regression for each rated packaged bond-year:

$$Rating_{i,t} = \beta_0 + \beta_1 ClimateRisk + BondControls + YearFE \tag{5.1}$$

where $ClimateRisk$ is the expected annual loss scaled by GDP, and $BondControls$ is a vector of bond control variables (detailed in Table 3) including the log of the total offering amount, the number of CUSIPs packaged in the issue, whether the bond is subject to state tax, the alternative minimum tax, and/or federal tax, and the length of the bond's term. Following Harris and Piwowar (2006), I include controls for the bond's complexity.

The results are shown in Table 4. I find that within the treatment group, the relationship between the bond's rating at issuance and the issuer's climate risk is negative and significant. Since New Orleans has the highest climate risk score of the coastline cities, I also test the same regression excluding New Orleans and the municipalities within 10km of New Orleans, and find similar results. However, there were only 45 bond issuances (1.1% of the original sample) issued by New Orleans and municipalities within 10km. The magnitude of this effect is relatively small, however, and would be unlikely to result in notch downgrades. For example, Miami has the second highest $ClimateRisk$ of 0.42, and the estimated impact on its numerically-scaled rating would be -0.31, which is less than one notch.

When expanding the treatment sample to include municipalities within 100km of the 19 cities, the coefficient on climate risk is still negative and significant at the 10% level. This is expected, since climate change risks should be lower for municipalities that are further away from the coastline. I also test at the credit rating agency level to see if this effect holds across the largest three credit ratings. Panel B of Table 4 shows that *ClimateRisk* has a significant and negative coefficient for bond ratings issued by Moody's and S&P, but not Fitch. However, when excluding New Orleans and nearby municipalities, the coefficient on *ClimateRisk* is significant and negative for Moody's-rated bonds only. This could indicate that Moody's is incorporating climate change risks or something correlated to climate change risks into its bond ratings.

Next, I test for differences in credit ratings between the treatment group and a control group. Because the treatment group is disproportionately made up of multiple large cities, there could be an insignificant difference in ratings. Larger cities tend to have better ratings, and there are not many large cities in non-coastal states to match. Thus, I create two treatment groups: (1) Treatment10, which is the original treatment group including municipalities within 10km of one of the 22 coastal cities, and (2) Treatment100, which includes municipalities within 100km of one of the 22 coastal cities.

I create a one-to-one control group by nearest neighbor matching at the municipality level. Since my current measure of climate risk does not include all municipalities on the coastline, I exclude all municipalities in all states that border the coastlines from the set of potential municipalities in the control group. I match on total tax to total revenues, population, total debt outstanding, population, income per capita, and median age in 2011, as well as number of bonds issued between 2011 to 2020 at the municipality level.

Table 5 shows the results of the matching for the treatment groups assigning *ClimateRisk*. The matched samples for both treatment and control groups are close in distance, although the matched sample for Treatment100 has a smaller matched standardized mean difference and standardized mean difference than Treatment10. However, the recommended threshold for the absolute standardized mean difference is 0.10, and the closer to zero, the better. Neither matched groups meet the threshold for total tax to total revenues, population, or the overall distance. However, Treatment10 has a standardized mean difference above the threshold for income per capita and median age, while Treatment100 does not.

The descriptive statistics for the treatment and control groups' bond issuances are shown in Table 6. For the matched sample using Treatment10, the number of rated bond issuances in the sample is 4,487, where 1,829 were issued by the control group municipalities and 2,658 were issued by the treatment group municipalities. The matched sample using Treatment100 has 15,349 rated bond issuance observations, where 8,564 were issued by the treatment group municipalities and 6,807 were issued by the control group municipalities. In both matched samples, the treatment group has a lower mean average bond rating than the control group.

I estimate the following for each matched sample:

$$Rating_{i,t} = \beta_0 + \beta_1 ClimateRiskInd + BondControls + YearFE \tag{5.2}$$

where $ClimateRiskInd$ is an indicator for whether the issuer has a $ClimateRisk > 0$. I cluster standard errors at the municipality level.

The results are shown in Table 7. $ClimateRiskInd$ has an insignificant coefficient for the matched sample with the treatment group within 10km of a coastal city, and a significant and negative coefficient for the matched sample with the treatment group within 100km of a coastal city. As mentioned before, the insignificant results for the matched sample with the treatment group within 10km of a coastal city could be a result of there not being many other large cities to match on in non-coastal states. However, when expanding the treatment assignment to 100km, matching improves because there are more small to mid-size municipalities in the treatment group to match.

I plan to identify all coastal municipalities in the future because of the limitations of my current measure. Including all municipalities within 10km of a treatment city makes it unlikely that I am capturing non-coastal municipalities, but results in a biased sample of mostly large municipalities. Since large cities tend to issue debt more frequently than smaller municipalities, my results using 10km may be insignificant because the number of bond issuances from larger municipalities (which tend to have better ratings) may constitute a majority of my sample. Meanwhile, including all municipalities within 100km of a treatment city increases the likelihood that I am capturing non-coastal municipalities. Another limitation I face is selection. Coastline municipalities with a high cost of debt may choose to not issue new bonds. I could potentially mitigate some selection issues by using ratings of bonds issued prior to 2011, instead of bond ratings at the time of issuance. Since coastline municipalities with a high cost of debt may choose to not issue new bonds, I could instead measure an average of ratings on general obligation and revenue bonds outstanding for a municipality.

Chapter 6

Conclusion

In this paper, I examine whether climate change risks are incorporated into municipal bond ratings. I measure climate change risk as the mean annual loss resulting from a 40cm increase in sea levels within 50 years, scaled by GDP for 22 large coastal cities, and assign the same climate risk score to municipalities within 10km of these coastal cities.

My preliminary findings suggest that climate change risks are at least partially incorporated into municipal bond ratings. I find a negative and significant relationship between my measure of climate risk and bond ratings for bonds issued by coastal municipalities between 2011 to 2020. I also document a negative difference in ratings between coastal municipalities and non-coastal municipalities. However, in both tests, the magnitude of the expected impact on the municipality's rating is less than a single notch. Taken together, it appears that this risk is only partially incorporated into ratings. My current methodology and analysis presents some limitations. My method of identifying coastal communities with high exposure to sea-level rise does not include municipalities that are not within 10km of a major coastal city. Thus, my treatment group is incomplete and disproportionately made up of large cities, which should bias against my results, since large cities are better positioned to invest in mitigation projects. In the future, I plan to use GIS data to accurately identify all coastal municipalities within the US.

I hope to contribute to the literature by offering insight into the extent to which climate change risks are incorporated into municipal bond ratings. Additionally, this study hopes to shed light on the financial impact of climate change for affected municipalities by examining the channels in which climate change risks are indirectly incorporated into ratings.

Chapter 7

Appendix

Table 1. Hallegatte's Climate Risk Scores for Major Cities

Below is the table of cities included in Hallegatte et al. (2013) and their estimated annual loss resulting from a 40cm sea-level rise, scaled by GDP, under the optimistic scenario. I extend the treatment group by assigning the same climate risk score to municipalities within my sample that are within 10km or 100km of the cities with climate risk scores.

			Number of Issuing Municipalities	
Municipality	State	Climate Risk	Within 10km	Within 100km
New Orleans	LA	1.479	0	7
Miami	FL	0.42	7	17
Tampa	FL	0.324	0	7
St. Petersburg	FL	0.324	(Same as Tampa)	
Virginia Beach	VA	0.173	4	8
Boston	MA	0.149	23	107
Baltimore	MD	0.104	0	2
Los Angeles	CA	0.097	19	82
Long Beach	CA	0.097	(Same as LA)	
Santa Ana	CA	0.097	(Same as LA)	
New York City	NY	0.089	6	83
Newark	NJ	0.089	(Same as NYC)	
Providence	RI	0.083	15	89
Philadelphia	PA	0.044	13	77
San Francisco	CA	0.042	9	30
Oakland	CA	0.042	(Same as San Francisco)	
Houston	TX	0.038	12	29
Seattle	WA	0.023	3	43
Washington	DC	0.016	2	10
San Diego	CA	0.004	6	13
Portland	OR	0.002	7	27
San Jose	CA	0.001	6	35
Total Additional Municipalities:			132	666
Total Municipalities:			154	688

Table 2. Descriptive Statistics: Bond Ratings Sample

This table reports descriptive statistics for municipal bonds issued between 2011 to 2020. Rating is measured on a numerical scale from 1 to 21 (21 being AAA). If the bond was rated by more than 1 credit rating agency, the average of the ratings is used. I split the full sample in to two groups based on their assigned climate risk scores. Total Taxes and Debt Outstanding are reported in $100,000s. $Personal2014$ and $Personal2020$ is the percent of respondents at the county-level that indicated in the Yale Climate Opinions Survey in the years 2014 and 2020 that they believed climate change would harm them personally; $Timing2014$ and $Timing2020$ is the percent of respondents at the county-level that indicated that they believed climate change change is already harming people in the US now or within the next 10 years.

	Full Sample			**Climate Risk > 0**			**Climate Risk = 0**		
	Mean	Med	SD	Mean	Med	SD	Mean	Med	SD
Issuance-level									
Climate Risk	0.01	0.0	0.06	0.09	0.1	0.17	0.00	0.0	0.00
Rating	18.42	19.0	1.88	18.58	19.0	1.95	18.40	19.0	1.88
Offering Amount ($M)	23.93	8.2	59.46	56.54	18.0	117.84	20.83	7.7	49.38
Maturity Years	16.16	16.0	7.80	17.09	18.4	9.08	16.07	15.9	7.67
CUSIPs/Issue	12.63	13.0	6.83	12.96	14.0	7.91	12.60	12.0	6.72
GO (%)	62.11			59.70			62.34		
Competitive (%)	61.08			49.08			62.23		
Put Option (%)	1.64			2.03			1.60		
Callable (%)	6.08			7.27			5.97		
Sink Fund (%)	33.12			34.89			32.95		
Insured (%)	16.64			14.06			16.89		
State Tax (%)	11.70			0.44			12.78		
Federal Tax (%)	9.77			11.61			9.59		
AMT (%)	0.85			2.23			0.72		
Observations	44,420			2,658			41,762		
Municipality-level									
Total Taxes	22.02	4.48	97.54	105.29	37.83	341.85	18.07	3.89	64.31
Debt Outstanding	75.83	8.80	578.49	323.36	44.03	1,711.34	65.55	7.92	477.23
Municipality Obs	5,921			154			5,767		
County-level									
Personal2014	32.25	31.0	3.70	38.67	38.00	4.62	32.06	31.00	3.50
Personal2020	37.54	36.19	5.01	47.33	48.10	5.86	37.25	36.05	4.68
Timing2014	39.82	39.00	3.59	46.74	46.00	4.80	39.62	39.00	3.33
Timing2020	50.63	49.27	5.54	61.56	62.00	5.63	50.31	49.09	5.19
County Obs	1,979			33			1,946		

Table 3. Variable Definitions

Variable	Definition
ClimateRisk	Climate risk score from (Table 1)
ClimateRiskInd	Indicator variable equal to 1 if the issuer has a $ClimateRisk > 0$.
Rating	The earliest credit rating (from a scale of 0 to 21, where 21 is AAA) provided by Fitch, Moody's, and/or S&P. If multiple credit rating agencies rated the bond, then the average rating is used.
State Tax	Indicator variable equal to 1 if the bond is subject to state tax.
AMT	Indicator variable equal to 1 if the bond is subject to the AMT.
Federal Tax	Indicator variable equal to 1 if the bond is subject to federal tax.
Offering Amount	The total offering amount in the issuer's bond issuance.
CUSIPs/Issue	Number of CUSIPs packaged in the issuance.
BondYears	Number of years between the offering date and the maturity date (if multiple CUSIPs per issuance, latest maturity date is used).
GO	Indicator variable equal to 1 if the bond's source of repayment is through the general obligation fund.
Competitive	Indicator variable equal to 1 if the bond's offering was competitive (as opposed to negotiated).
Put Option	Indicator variable equal to 1 if the bond has a put option.
Callable	Indicator variable equal to 1 if the bond is callable.
Insured	Indicator variable equal to 1 if the bond is insured.
Sink Fund	Indicator variable equal to 1 if the bond has a sinking fund provision.

Table 4. Effect of climate risk on the treatment group's ratings

The table below shows the results of Equation 5.1 for the bonds issued between 2011 to 2020 by municipalities within 10km of a city with a $ClimateRisk > 0$. The municipalities included are assigned the same $ClimateRisk$ as the closest city in the original 22 cities. In Panel A, the dependent variable is the bond rating or the average bond rating if the bond was rated by more than one of the three credit rating agencies. The variable of interest is $ClimateRisk$. The sample excluding New Orleans excludes all bond issuances by New Orleans and the municipalities within 10km of New Orleans. Panel B shows the results using the bond rating by credit rating agency as the dependent variable. The reported t-statistics in parentheses are based on errors clustered by municipality. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Panel A: Treatment group, average bond rating

	Full Sample	No New Orleans
ClimateRisk	−1.09 **	−0.73 *
	(−3.46)	(−1.67)
(*Intercept*)	17.09 ***	17.01 ***
	(26.66)	(26.31)
Bond Controls	Yes	Yes
Year FE	Yes	Yes
Adj R2	0.451	0.441
Obs	2,658	2,613

Panel B: Treatment group, bond ratings by credit rating agency

	Full Sample			No New Orleans		
	Moody's	S&P	Fitch	Moody's	S&P	Fitch
ClimateRisk	−4.04 ***	−3.34 **	−1.56	−1.98 **	−0.10	−1.50
	(−3.10)	(−1.98)	(−0.29)	(−2.10)	(−1.10)	(−0.28)
(*Intercept*)	16.23 ***	16.82 ***	16.62 ***	16.20 ***	16.96 ***	16.50 ***
	(14.25)	(21.51)	(10.14)	(14.17)	(19.32)	(14.01)
Bond Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Adj R2	0.453	0.377	0.458	0.411	0.370	0.444
Obs	1,387	2,271	238	1,360	2,229	231

Table 5. Matching

The table below shows the descriptive statistics for the treatment and control group for two different treatment groups. Panel A shows the matching results for the treatment group that includes municipalities within 10km of a coastal city and Panel B shows the matching results for municipalities within 100km of a coastal city. The set of potential control group municipalities includes all municipalities in non-coastal states.

Panel A: Treatment10 (Treatment Group within 10km of Coastal City)

	Treatment Mean	Full Control Mean	Matched Control Mean	Matched Std. Mean Difference	Matched Pair Distance
Taxes/Revenue	0.56	0.38	0.62	-0.37	1.05
Total Debt Outstanding	782,064	60,391	235,249	0.07	0.12
Population	1,858,924	115,025	584,488	0.39	0.47
Income per capita	35,122	26,017	37,307	-0.19	1.06
Median Age	37.90	39.35	38.77	0.28	1.35
Bonds Issued	17.26	6.86	11.87	0.08	0.28
Distance	0.32	0.06	0.24	0.25	0.25
Municipalities	154	3,405	154		

Panel B: Treatment100 (Treatment Group within 100km of Coastal City)

	Treatment Mean	Full Control Mean	Matched Control Mean	Matched Std. Mean Difference	Matched Pair Distance
Taxes/Revenue	0.57	0.38	0.59	-0.20	1.02
Total Debt Outstanding	388,617	60,391	144,657	0.05	0.10
Population	1,273,914	115,025	362,486	0.30	0.45
Income per capita	36,897	26,017	35,650	0.01	0.85
Median Age	38.63	39.35	38.78	-0.03	1.36
Bonds Issued	12.44	6.86	9.89	0.06	0.31
Distance	0.43	0.12	0.39	0.19	0.21
Municipalities	688	3,405	688		

Table 6. Matched sample descriptive statistics

The table below shows the descriptive statistics for the bonds issued by the matched treatment and control group. Panel A shows the matching results for Treatment10, the treatment group that includes municipalities within 10km of a coastal city. Panel B shows the results for Treatment100, the treatment group that includes municipalities within 100km of a coastal city.

Panel A: Treatment10 (Treatment Group within 10km of Coastal City)

	Full			Treatment			Control		
	Mean	Med	SD	Mean	Med	SD	Mean	Med	SD
Climate Risk	0.05	0.0	0.13	0.09	0.1	0.15	0.00	0.0	0.00
Rating	18.62	19.0	2.04	18.58	19.0	1.91	18.67	19.0	2.19
Bond Years	16.67	17.0	9.25	17.88	19.3	9.85	15.16	15.0	8.19
Offering Amount ($M)	64.63	15.8	143.2	86.93	25.5	173.6	36.81	9.6	84.30
CUSIPS/Issue	11.66	12.0	8.13	11.92	12.0	8.86	11.35	11.0	7.09
State Tax (%)	10.77			0.48			23.61		
GO (%)	51.41			45.47			58.83		
Competitive (%)	52.31			51.27			53.60		
Put Option (%)	5.30			7.40			2.68		
Callable (%)	6.67			6.81			6.49		
Sink Fund (%)	30.68			34.56			25.85		
Insured (%)	11.67			12.26			10.92		
Federal Tax (%)	11.85			12.31			11.28		
AMT (%)	2.23			2.72			1.62		
Issuance Obs	4,487			2,658			1,829		

Panel B: Treatment100 (Treatment Group within 100km of Coastal City)

	Full			Treatment			Control		
	Mean	Med	SD	Mean	Med	SD	Mean	Med	SD
Climate Risk	0.05	0.0	0.11	0.09	0.1	0.13	0.00	0.0	0.00
Rating	18.72	19.0	1.91	18.62	19.0	1.87	18.85	19.0	1.94
Bond Years	16.31	16.4	8.74	17.31	18.6	9.29	15.11	15.1	7.86
Offering Amount ($M)	45.63	11.4	113.1	59.87	16.0	137.1	28.46	8.7	70.84
CUSIPS/Issue	12.21	12.0	7.62	12.56	13.0	8.18	11.79	12.0	6.85
State Tax (%)	9.62			0.50			20.63		
GO (%)	57.74			56.68			59.01		
Competitive (%)	57.48			55.80			59.51		
Put Option (%)	3.39			4.59			1.94		
Callable (%)	5.66			5.79			5.49		
Sink Fund (%)	30.61			33.42			27.21		
Insured (%)	11.15			14.45			7.16		
Federal Tax (%)	10.78			10.55			11.05		
AMT (%)	1.45			1.66			1.21		
Issuance Obs	15,349			8,564			6,807		

Table 7. Matched sample test

The table below shows the results of Equation 5.2 for the bonds issued between 2011 to 2020 by the matched treatment and control municipalities. Treatment10 is the sample of bond issuances from the treatment group of the 22 coastal cities and the municipalities within 10km of the coastal cities, and the bond issuances from the matched control group. Treatment100 is the sample of bond issuances from the treatment group of the 22 coastal cities and the municipalities within 100km of the coastal cities, and the bond issuances from the matched control group. *ClimateRiskInd* is an indicator variable for whether the bond's issuer has a *ClimateRisk* > 0, and is the variable of interest. I test using the full matched sample and the full matched sample excluding bonds issued by New Orleans and the nearby municipalities and its respective control municipalities. The reported t-statistics in parentheses are based on errors clustered by municipality. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

	Treatment10			
	Full Sample	No New Orleans	Full Sample	No New Orleans
ClimateRiskInd	−0.06	−0.04	0.81 ***	0.83 ***
	(−0.42)	(−0.33)	(5.93)	(6.00)
Bond Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
State FE			Yes	Yes
State×Year FE			Yes	Yes
Obs	4,487	4,434	4,487	4,434
Adj R2	0.330	0.328	0.401	0.397

	Treatment100			
	Full Sample	No New Orleans	Full Sample	No New Orleans
ClimateRiskInd	−0.18 **	−0.17 *	0.83 ***	0.83 ***
	(−2.05)	(−1.92)	(3.02)	(3.03)
Bond Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
State FE			Yes	Yes
State×Year FE			Yes	Yes
Obs	15,349	15,216	15,349	15,216
Adj R2	0.323	0.321	0.364	0.363

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