An inconvenient cost: the effects of climate change on municipal bonds

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Abstract

Counties more likely to be affected by climate change pay more in underwriting fees and initial yields to issue long-term municipal bonds compared to counties unlikely to be affected by climate change. This difference disappears when comparing short-term municipal bonds, implying the market prices climate change risks for long-term securities only. Higher issuance costs for climate risk counties are driven by bonds with lower credit ratings. Investor attention is a driving factor, as the difference in issuance costs on bonds issued by climate and non-climate affected counties increases after the release of the 2006 Stern Review on climate change.

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1. Introduction

In this paper, I examine whether the municipal bond market prices climate change risk. The potential financial losses posed by climate change have caused growing concern among investors, with climate change being a top shareholder proposal issue in recent years (ISS, 2018). For example, in Berkshire Hathaway's 2015 annual letter to shareholders, CEO Warren Buffett responded to a proxy proposal that would require Berkshire to provide an annual report on how their insurance operations are responding to the threats of climate change:

> *"The sponsor [of the proxy] may worry that property losses will skyrocket because of weather changes. And such worries might, in fact, be warranted if we wrote ten- or twenty-year policies at fixed prices. But insurance policies are customarily written for one year and repriced annually to reflect changing exposures. Increased possibilities of loss translate promptly into increased premiums."*

While insurance companies are able to adjust to increased risks by annually repricing policies, other investments cannot be as responsive to avoid potential climate change costs. In particular, municipalities in areas that are expected to be greatly affected by sea level rise would not be able to avoid the costs associated with repairing damaged infrastructure. This leads to an important question: do investors price climate change risk when this risk cannot be easily addressed?

The municipal bond market provides a useful setting to study this question, as municipalities are unable to relocate away from climate change risk in the way a corporation could. For example, if the Folgers Coffee Company felt its New Orleans factory was at risk of being damaged by sea level rise, they could relocate the factory to a location with less climate change risk and face little financial consequence. Orleans Parish, however, cannot relocate its infrastructure and thus cannot reduce climate change risk as easily. Therefore, investors are more likely to account for climate change risk when investing in municipal bonds as opposed to corporate bonds or stocks.

Furthermore, municipal bonds are heterogeneous in term structure. This feature leads to different expected climate change risk for bonds with different maturities. Because climate induced sea level rise is likely to cause more damage in two decades compared to two years, municipal bonds with longer maturities are more likely to be affected by climate change. If investors are concerned about climate risk, then municipalities more likely to be affected by climate change (climate bonds) should face higher issuance costs for long-term bonds compared to municipalities less likely to be affected (non-climate bonds). However, investors are unlikely to require a premium for short-term bonds issued by counties with higher climate risk.

To address the question of how climate change risk affects municipalities, I examine whether the cost of issuing municipal bonds is affected by the exposure a county has to climate change as measured by expected mean annual loss from sea level rise as a percentage of GDP. This measure of climate risk comes from Hallegatte, Green, Nicholls, and Corfee-Morlot (2013), who predict global losses to coastal cities based on a 40cm rise in sea level. I measure the annualized cost of issuing municipal bonds as the sum of the initial bond yield and the annualized gross spread.

I find that, on average, a one percent increase in climate risk for a county is associated with a statistically significant increase in annualized issuance costs of 23.4 basis points for long-term maturity bonds. This additional issuance cost is economically significant, as a one percent increase in climate risk is associated with an average rise in total annualized issuance costs of $1.7 million for the average county. However, when looking at short-term maturity bonds, I find no significant difference in issuance costs between climate and non-climate bonds. The difference in issuance costs based on term structure is robust to a variety of specifications for defining long-term and short-term bonds. Moreover, placebo tests show no relation between climate risk and long-term bond issuance costs for neighboring non-coastal counties. Together, these findings suggest that investors are able to identify investments with a higher risk of being affected by climate change and that the market prices this risk.

I next examine heterogeneity in the credit ratings of municipalities. Bond rating agency Moody's recently issued a report warning coastal counties that if they are unprepared to deal with climate change damage they will face credit downgrades.[1] The report states that Moody's expects lower rated counties to be more susceptible to climate change risks, as they generally have weaker infrastructure and smaller fiscal capacity. Bond ratings affect the prices of municipal bonds as investors rely on them to assess credit risk (Cornaggia, Cornaggia, and Israelsen (2017)). Additionally, ratings have important effects on local economies. Adelino, Cunha, and Ferreira (2017) find that local government expenditures and employment are positively related to bond ratings. If investors already price sea level rise risk into their municipal bond investments (especially for poorly rated bonds), then Moody's downgrades could create an unnecessary burden for climate affected counties.

My results show that investors recognize that poorly rated bonds are more susceptible to climate change risk, as the significant difference in issuance costs between climate and non-climate bonds is driven by bonds with lower credit ratings (i.e. below an S&P rating of AA- or a Moody's rating of Aa3). This result suggests the market is able to price climate change risk with regard to credit quality, raising the question as to whether the potential Moody's downgrades based on climate risk are necessary.

To further identify whether investors are taking climate change risks into account, I conduct a quasi-natural experiment comparing issuance costs before and after a significant event related to climate change that affects whether investors pay attention to this risk. In the experiment I examine the release of Nicholas Stern's "Economics of Climate Change" Review (Stern, 2008), a widely discussed report released in 2006 that emphasizes the

[1] "Moody's Warns Cities to Address Climate Risks or Face Downgrades" Bloomberg. November 2017

potential irreversible damages climate change may cause if it is not addressed. Before the release of the Stern Review, I find no significant difference in the total annualized cost of issuance between climate and non-climate bonds. However, after the release of the Stern Review the difference in total annualized cost of issuing long-term climate bonds versus long-term non-climate bonds increases significantly. Short-term bond issuance costs are unaffected by the release of the Stern Review. These results suggest that investors became more aware of climate change risks after the release of the Stern Review and began pricing these risks into their investments.

Little is known about how long-term climate change risk is priced in financial markets. Hong, Li, and Xu (2017) focus on climate change induced drought and find that markets under-react to this risk. However, Bansal, Kiku, and Ochoa (2016) find that climate change risk as proxied by temperature rise has a negative impact on asset valuations, implying markets do price climate change risk. In the real estate market, Bernstein, Gustafson, and Lewis (2017) find that homes exposed to sea level rise sell at a discount relative to otherwise similar unexposed homes. My findings contribute to the evidence that the market does react to climate change risks. Further, my results suggest that investor attention is an important factor regarding whether climate change risk is priced, as municipal bond investors do not start pricing climate risk until after the release of the Stern Review. Notably, the debate over the existence of climate change is irrelevant to my findings. Rather, the results suggest that investors require a premium for the increased uncertainty as to whether they will see a return of capital from investments in municipalities with climate risk, regardless of whether the risk is actually realized.

This paper also contributes to the literature that studies the financial consequences of climate change. Financial consequences of climate change come in four general forms: production risk, reputation risk, regulatory/litigation risk, and physical risk. Hong et al. (2017) show that production risk from prolonged droughts forecasts a negative effect on the stock returns of firms in the food industry. Dell, Jones, and Olken (2012) find that higher temperatures can reduce agricultural and industrial output. Chava (2014) shows that investors require a higher cost of capital for firms excluded by environmental screens. These firms either face the reputation risk of being labeled contributors to climate change or face regulatory risk because current output could be negatively affected by future climate change related regulation. Bernstein et al. (2017) show that the physical risk of sea level rise negatively affects the price of exposed homes. However, they find little evidence that prices are affected by sea level rise when the housing market is particularly liquid. My findings add to this literature by showing that investors are concerned about the physical risk of climate change on assets traded in a liquid market and that these investors subsequently price in this risk on the assets they hold.

Finally, this paper adds to the literature on the determinants of municipal bond issuance costs. Relevant factors for issuance costs include market transparency (Schultz, 2012), the location of the bond underwriter (Butler, 2008), credit rating (Cornaggia et al., 2017), and local government policy (Gao, Lee, and Murphy, 2017). To my knowledge, this paper is the first to provide empirical evidence of the effects of climate change on bond markets and local government financing.

2. Municipal bonds and issuance costs

Municipal bonds are debt issued by state or local governments, typically for the purpose of funding public projects like roads, buildings, utilities, or other infrastructure. This debt is then paid back by the municipality using either tax revenue (i.e. general obligation bonds) or other sources of revenue that come from the project (i.e. revenue bonds). For example, a bond issued to fund the building of a parking garage could then be paid back using the revenue from selling parking passes to the garage. General obligation bonds are seen as less risky because municipalities are able to raise taxes in the event that there is not enough funds to pay all debtholders.

When municipalities issue debt, they employ underwriters to structure the deal and to sell the bonds to investors. Underwriters are compensated by what is referred to as the gross spread. The gross spread is the difference in price between what the underwriters pay to buy the bonds from the municipality and what they earn when they sell the bonds to the market, assuming the bonds are sold at issue price. If the bonds are sold at a higher price than the issue price, the underwriter's total profit increases, and vice versa. A higher gross spread indicates higher search costs for the underwriter to complete the issuance.

Gross spread is a common proxy for the demand for debt in finance literature. Dougal, Gao, Mayew, and Parsons (2018) use gross spreads to determine the difference in demand for bonds issued by historically black colleges and non-historically black colleges. Butler (2008) uses gross spreads to show that local investment banks are better suited to issue high-risk and nonrated bonds.

Once the municipality and underwriter agree on a gross spread, the underwriter then issues the bonds to the market at the highest price (lowest yield) they can while still selling the entire bond issue. Therefore the yield at issuance of a bond also informs us as to how much demand a particular bond issue is receiving. I measure the total annualized cost to issue a bond as the annualized gross spread of a bond plus the bond yield. It is necessary to annualize gross spread into equivalent payments over the life of a bond because gross spread is a one-time payment whereas yield is an annual cost. I annualize gross spread by taking the geometric average of gross spread scaled by the bond's maximum maturity at issuance.

If investors see climate change as a potential risk of investment, then underwriters would have higher search costs when marketing a bond issuance and investors would require a higher yield to compensate for the additional risk. This leads to the main hypothesis of the paper: municipal bonds with higher exposure to climate change risk will have higher issuance costs, on average.

3. County rankings on climate change exposure

This paper focuses on climate change risk stemming from climate-induced sea level rise. Though there are several forms of climate change risk (e.g. extreme precipitation, extreme drought, and urban heat islands), sea level rise is one of the most significant risks and the risk most studied by climatologists. The main variable I use to measure climate change risk, the mean annual loss as a percentage of GDP, comes from a study by Hallegatte et al. (2013) that predicts global losses based on a 40cm rise in sea level and assuming cities attempt to adapt to the rise in sea level (e.g., upgrading dikes and sea walls). The following discussion of their specific methodology paraphrases some of the information from the supplemental file to Hallegatte et al. (2013).

Hallegatte et al. (2013) first use elevation-based Geographical Information Systems to compute population exposure in each 50 cm "elevation layer" from the current mean sea level. They then translate the exposed population into exposed assets using estimates of the amount of capital per inhabitant. For current defense levels in coastal cities, the authors follow the methodology of Linham, Green, and Nichollas (2010). When assessing flood losses, Hallegatte et al. (2013) assume that when the water level is below the defense level for a city, the failure probability is zero, even if the water level is higher than the sea level of the city. To translate exposed assets as a function of water level into asset losses, each elevation layer is assigned one of six categories: (1) lightweight-timber-framed dwellings; (2) masonry dwellings; (3) low-income-country dwellings; (4) dwelling contents; (5) non-residential structures; and (6) non-residential content. Mean annual flood losses are then estimated using the probability of flood losses at each water level. The authors assume climate-induced sea level rise is homogeneous and that storm surge likelihood will not change due to sea level rise. The study also considers several other drivers of floods, including demographic and socio-economic changes and human-induced subsidence.

Table 1 presents each US city included in Hallegatte et al. (2013), ranked by climate risk. As municipal bonds are issued at the county level, I match the ranked cities with their associated counties. Table 1 shows that most climate change risk is concentrated in a few counties. The city with the highest climate risk is New Orleans, LA, which is expected to have a mean annual loss to GDP of 1.48% due to sea level rise. Notably, low climate risk in percentage terms can still mean large potential losses in dollar terms. For example, although New York/Newark's climate risk is only 0.09%, they are still expected to have annual losses of over $2.1 billion.

A shortcoming of using the estimates of the Hallegatte et al. (2013) study is that I am only able to observe climate risk estimates for major coastal cities. Fortunately, the affected counties still account for a significant 15% of the total number of issuances in my sample. However, potential biases may still occur. First, it is possible to find spurious results due to the relatively small number of counties. I address this possibility by conducting placebo tests for affected counties in Section 5.2. Second, I assume coastal counties not measured in Hallegatte et al. (2013) have a climate risk of zero, even though these counties will likely be negatively affected by sea level rise. This assumption is not a major concern as it biases against finding a significant result. Nevertheless, I ensure that my results are robust to the exclusion of all unobserved coastal counties.

4. Data

I obtain data on municipal bond offerings from Bloomberg. The data for new issues is restricted to bonds with issue sizes above one million dollars and that are rated by either Standard & Poor's or Moody's. Additionally, I exclude bonds for which both the gross spread and initial yield are unavailable.[2] The final sample contains 327,152 municipal issues, 50,914 of which are issued in counties with a climate risk above zero.

[2]Bloomberg denotes the gross spread as the issuance discount spread and gives the following definition: "Security issuance underwriter discount costs (including spreads, takedown, and underwriting fees disclosed by the underwriter in official documents accompanying the sale) expressed as a percentage of the total issued amount."

Table 2 presents the descriptive statistics for the bond data separated by climate and non-climate bonds. The bond issues range from January 2004 to March 2017. In a univariate setting, climate counties on average pay 6 basis points less in gross spread and 11 basis points more in initial yield. Bonds issued by climate counties on average pay 3.03% in total annualized costs to issue a bond, compared to 2.95% for non-climate counties. For climate (non-climate) bonds, the average issue size is $13.4 ($8) million and the average maximum maturity is 14.63 (13.57) years. Over half of the bonds (61% and 60%) in the sample have a call provision, 15% (16%) are insured, 18% (19%) have a sinking provision, 40% (49%) are general obligation bonds, and 6% (7%) are pre-refunded. The majority of the bonds are tax-exempt, 85% (81%) federally exempt and 77% (75%) state exempt. Bonds subject to the alternative minimum tax (AMT) make up 4% (3%) of the sample. AMT's tend to have higher yields which reflects the risk that they could become taxable to some investors in the future, based on changing income levels. The average underwriter issued 16,820 (14,530) bonds during the sample period.

Following Cantor and Packer (1997) I convert Standard & Poor's and Moody's rating scales into numeric form. The highest rated bonds (AAA or Aaa) are given a value of one, bonds with ratings of AA+ or Aa1 are given a value of two, and so forth. Therefore the median sample rating of three indicates that the median rating assigned by Standard & Poor's (Moody's) is AA (Aa2). In the case where both credit agencies rate a bond, I use Standard & Poor's rating. This is because in the past Moody's was more likely to assign unsolicited ratings that are likely to have a downward bias.[3]

Municipalities may choose underwriters through either negotiated or competitive offerings. A negotiated offering occurs when the issuer and an underwriter come to a contractual agreement that the underwriter will have exclusive rights to distribute the

[3]Unsolicited ratings are ratings assigned by an agency that were not requested by an issuer (i.e. the issuer does not pay the rating agency to assign a rating). Unsolicited ratings have been criticized as a form of extortion, as agencies assign lower ratings when they are not hired by the issuer (Butler and Cornaggia, 2012).

issue. In a competitive offering, multiple underwriters bid for the rights to issue the bond, with the winning bid being the one with the lowest issuance cost to the municipality. Controlling for the type of underwriting procedure is important as the type of offering is an important factor in the cost of the issue. Competitive offerings tend to be less costly for the municipality when there are many bids, but negotiated offerings can be cheaper if there are few underwriter bids (Kidwell and Sorensen, 1983). The new issuance sample consists of 23% (28%) competitive and 77% (72%) negotiated offerings.

Municipalities often employ underwriters to issue multiple bonds in one package. Bonds included in a package tend to have a similar purpose (i.e. each bond is issued to fund the same project) but will differ in characteristics like maturity. Each maturity is assigned a separate CUSIP that is used as an identifier for trading on the secondary market. The mean (median) packaged issue for climate bonds has 12.77 (10) CUSIPs while the mean (median) packaged issue for non-climate bonds has 10.81 (9) CUSIPs.

Panel B of Table 2 details the total annualized issuance cost, yield, gross spread, and percentage of climate bonds broken down by maximum maturity and rating. The main identification strategy I use to identify long-term versus short-term bonds is whether or not the bond's maximum possible maturity is above or below 25 years. Bonds with a maximum maturity of 25 years or greater at issuance make up nearly 10% of the sample. Assuming investors are rational, I expect to see higher issuance costs for long-term climate bonds compared to long-term non-climate bonds, but no significant difference between short-term bonds. Climate change studies differ in their forecasts for when sea level rise will significantly damage coastal areas, ranging from as early as 2030 until past 2100 (Tol, 2009). To ensure that my results are not unique to the 25 year sample split, I confirm that my results are robust to a variety of term structure cutoffs in Section 5.2. The average total annualized cost is 4.66% for bonds with a maturity of 25 years or more and 2.82% for bonds with a maturity of less than 25 years.

Although there are relatively few counties with an observed climate risk, they represent a significant portion of the sample. This is likely because counties with an identified climate risk are among the largest in the country and therefore need to issue proportionally more bonds to fund their operations. The percentage of climate bonds in each subcategory (12.5% to 19.8%) is consistently close to the percentage of climate bonds in the total sample (15.1%). As expected, the last four rows of Panel B show that total annualized issuance cost, yield, and gross spread all increase monotonically as ratings decline.

5. The effect of sea level rise on municipal bond issuance costs

To examine the effects of an increase in climate risk on the cost to issue a municipal bond, I estimate the following model:

$$\begin{aligned} Total\ Annualized\ Issuance\ Cost = \beta_1 * Climate\ Risk + \beta_2 * Bond\ Controls\ + \\ \beta_3 * State \times Year\ FE + \epsilon \end{aligned} \tag{1}$$

Following the municipal bond literature, I include controls for the log of the issue size, the log of the maximum maturity, the bond's initial credit rating, the log of the number of CUSIPS packaged in the same issue, the log of the number of underwriter deals that the bond's underwriter has issued in the sample, and indicator variables for whether the bond is callable, insured, sinkable, pre-refunded, funded by general obligation, competitively issued, federally tax-exempt, state tax-exempt, or subject to AMT. I also include state-year fixed effects. The fixed effects control for the possibility that climate affected counties tend to issue bonds when issuance costs are relatively high as well as the possibility that the climate risk measure captures unobserved cross-state factors. All standard errors are clustered by the county of issuance, as the residuals of the regressions could be correlated within counties.

5.1. Main results

Table 3 presents the results for the effect of climate risk on issuance costs. Panel A compares results for total annualized issuance costs for long-term and short-term bonds, based on whether their maximum maturity is greater than or less than 25 years. The first three columns show that long-term bonds are more costly to issue when there is an increased risk of sea level rise for a county. Column 1 shows the relation between climate risk and total issuance cost when controlling for three primary determinants of issuance costs: the size, maturity, and credit rating of the bond. Under this specification, a one percent increase in climate risk is associated with a 33.3 basis point increase in the total annualized issuance cost of a bond, significant at the 1% level. Given the unconditional average cost of a long-term issuance is 4.66%, this represents a 7.1% increase from the mean annualized issuance cost. Similar to other findings in the municipal bond offering literature, I find that issuance costs are higher for bond issuances of smaller size, longer maturity, and a worse credit rating.[4]

In column 2 I add the rest of the controls for bond issuance characteristics that can affect issuance costs. Climate risk remains a significant factor for issuance costs, as a one percent increase in climate risk is associated with a 23.4 basis point increase in total annualized cost. This represents a 5.0% increase from the mean annualized issuance cost. In economic terms, a one percent increase in climate risk would increase the total annualized cost of issuing a long-term bond of average size ($27.5 million) by $64,350. The average county issues 26.32 long-term bonds during the sample period, bringing the total burden of a one percent increase in climate risk to an additional $1,693,692 in annualized issuance costs for the average municipality.

The final three columns of Table 3 Panel A present results for short-term bond issuances.

[4]Recall that rating was converted to a numeric scale. Therefore a higher numeric rating represents a lower credit rating. In unreported tests, I substitute the rating control with rating fixed effects and find qualitatively similar results.

The magnitude for climate risk is reduced to between 7.7 and 9.3 basis points and is insignificant in all specifications. This loss of significance is particularly striking when considering that the sample of short-term bonds is nearly 12 times larger than the sample for long-term bonds.

Panels B and C of Table 3 break down total annualized issuance cost into its components of initial yield and gross spread. Columns 1 and 2 of Panel B show that investors require between a 16 and 20 basis point higher yield to invest in a long-term bond with a one percent higher climate risk. For short-term bonds, the magnitude on climate risk is reduced to between 7 and 7.9 basis points and is insignificant in both specifications. Panel C shows that underwriters also require a higher compensation to issue municipal bonds with climate risk. A one percent increase in climate risk is associated with between a 10.8 and 15.1 basis point increase in gross spread for long-term bonds. Climate risk once again does not appear to be a factor for short-term bonds, with an insignificant coefficient between -0.4 and 1.9 basis points.[5]

One possible concern when interpreting the climate risk coefficient is the possibility that a few counties with relatively high climate risk are driving the results. I address this concern in two ways. First, I log-transform climate risk to reduce the influence of outlying counties. Under this specification, the coefficient on climate risk remains significant at the 5% level, with a magnitude of 0.339. I use the log of climate risk in all subsequent tests to ensure that outliers in terms of climate risk are not driving the results. Second, because New Orleans is an outlier in terms of climate risk, I drop all observations of municipal issuances in Orleans Parish and re-estimate the model in equation 1. The results using the sample with Orleans Parish excluded are shown in the first two columns in Panel A of Table 4. Climate risk (log of climate risk) is still a significant predictor of annualized issuance costs under this specification, with a significant coefficient of 0.379 (0.441). These

[5]In the interest of parsimony, for subsequent tests I report results for the annualized total cost measure only. Results for the separate analyses of yields and gross spreads can be found in the appendix.

results imply that the effect of climate risk on issuance costs is not driven by risk factors specific to New Orleans.

I next examine the relationship between climate risk and issuance costs with all "unobserved" coastal counties omitted. In the main specification I assume that all cities that were not measured by Hallegatte et al. (2013) have a climate risk of zero. This assumption should bias against finding significant results, as these unobserved coastal counties likely do have risks associated with sea level rise. Indeed, I find a stronger association between climate risk and annualized issuance costs when unobserved counties are dropped. Columns 3 and 4 in Panel A of Table 4 report the results. I find a coefficient on climate risk (log of climate risk) of 0.366 (0.414), which is 56% (22%) higher than the coefficient of 0.234 (0.339) in the main specification. Insignificant results are once again found for short-term issuances when estimating the model with Orleans Parish dropped and with unobserved coastal counties dropped. Together, the evidence in Tables 3 and 4 suggest investors and underwriters require a premium to accept climate change risk, and this premium varies based on the magnitude and time horizon of climate risk.

5.2. Robustness analyses

Even after controlling for observables in a multivariate regression, there still exist potential concerns regarding whether the results in Table 3 are precisely identifying the effect of climate risk on municipal offering costs. One possible concern is that the choice of the term structure cutoff does not identify what an investor would see as the cutoff for short-term and long-term bonds. Another possibility is that the small number of climate risk counties is creating a spurious result and not actually identifying climate risk. In this section, I attempt to mitigate these concerns.

To ensure that investors do take into account the time horizon factor of climate risk, I conduct several robustness tests in which I vary the definition of long-term versus short-term bonds. I first test whether the results still hold when long-term (short-term) bonds are identified as those with a maturity of 20 or more (less than 20) years. I repeat this test using a cutoff of 30 years as well as varying the maximum maturity date to be 2036, 2041, or 2046. The choice to use a date as the cutoff in addition to maximum maturity at issuance is to account for the possibility that investors see climate change risk being more likely after a certain target date that may have been referenced in the media or a scientific study. The years 2036, 2041, and 2046 were chosen as they are 20, 25, and 30 years after the final full year of data in my sample, respectively.

Table 5 presents the results for the varying term structure splits. Panel A shows that, regardless of specification, climate risk is significantly related to the total annualized issuance cost of long-term municipal bonds. Further, the coefficient on the log of climate risk monotonically increases with the length of the term structure cutoff point. For the shortest cutoffs, the 20 year and 2036 splits, the magnitude on the log of climate risk is 19.8 and 20.5 basis points, respectively. For the longest cutoffs, the 30 year and 2046 splits, the coefficients for climate risk increase to 65.6 and 154 basis points, respectively. Panel B reports the results for the various short-term specifications. Consistent with the main results, investors do not require a premium for climate risk when the bonds mature earlier. Across all specifications, the coefficient on the log of climate risk is insignificant and smaller in magnitude compared to its long-term counterpart.[6] These results support the argument that investors require a higher premium for climate change risk when the time horizon of the investment is longer.

I next address the possibility that the small number of climate risk counties is creating spurious results by conducting two placebo tests using counties unlikely to be affected by sea level rise. In the first test, I identify placebo counties geographically, assigning the climate risk of a county to the closest non-coastal county. The placebo counties are likely to experience similar economic conditions compared to the climate affected counties.

[6] Results are qualitatively similar for the specifications with New Orleans dropped and with unobserved coastal counties dropped (see Table A.1).

Therefore, a significant coefficient on climate risk in the placebo test would suggest the climate risk measure is identifying unobserved local traits rather than risk due to sea level rise. However, an insignificant coefficient on climate risk would suggest the measure is accurately identifying climate risk.

In the second test, I identify placebo counties by conducting a nearest neighbor matching test based on the propensity to be a climate affected county. I match to the nearest neighbor based on the size of issuances, the number of CUSIPs per issue, the total number of issues by the county in the sample, and credit rating. These variables are used to identify counties with similar sized economies and fiscal capacities. I require all matched counties to be in non-coastal states to reduce any likelihood that these counties would be affected by sea level rise. I then assign the climate risk of affected counties to their nearest neighbor matched counties and test the main model specification on the placebo bonds. An insignificant coefficient on climate risk for this placebo test would suggest that the main results are correctly identifying the relationship between climate risk and issuance costs.

Table 6 presents the results of the placebo tests. I include results for all term structure cutoffs. Panel A presents results for the test using the closest non-coastal neighbors as placebo counties. The coefficient on the log of climate risk is insignificant across all specifications, implying that unobserved local conditions are not driving the main result. Panel B shows results using the nearest neighbor matching placebo test. Again, the coefficient on the log of climate risk is insignificant in all tests, implying that the results for the actual climate affected counties are not spurious. Together, these robustness tests provide evidence that climate risk and term structure are accurately identified and suggest a causal link between climate risk and municipal bond issuance costs.

5.3. Credit rating split

Moody's recent report detailing how they will assess the credit impact of climate change risk mentions varied expectations for how counties with different credit ratings will adapt to these risks:

> *"Higher rated sovereigns tend to be less susceptible to climate change risks, since they generally have more diversified economies, stronger infrastructure and a greater ability to carry a higher debt burden at more affordable interest rates. In contrast, sovereigns with a greater reliance on agriculture, lower incomes, weaker infrastructure quality, and smaller fiscal capacity exhibit greater susceptibility to the physical effects of climate change."*

The ability to carry a higher debt burden is of particular importance. Though the Federal Emergency Management Agency (FEMA) will likely assist with some of the costs of damages due to sea level rise, affected counties will still be expected to pay for a significant portion of the expenses.[7] Additionally, aid from FEMA takes time to be approved and disbursed, requiring municipalities to cover the costs of repair until federal assistance arrives. Covering disaster costs will be especially difficult for municipalities whose finances are already under pressure as the flooding could lead to lost tax revenues, either through lost revenue from unusable infrastructure or through a shrinking population which would erode the taxable base.[8] Therefore, counties with more financial flexibility will be better able to deal with the expected damages of sea level rise. If investors recognize this heterogeneity in financial flexibility, then the increase in issuance costs for climate affected municipal bonds should be driven by counties in poorer financial health. Further, if the market already recognizes the asymmetric effect of climate risk on lower rated municipal bonds, then Moody's potential downgrades may not be necessary.

[7]After a state of emergency is declared, FEMA provides supplemental assistance for state and local government recovery costs, with the Federal share being at least 75% of eligible expenses.
[8]"Do hurricanes pose a risk to the muni bond market?" Charles Schwab. September 2017

To test whether the risk premium that investors and underwriters require for climate change differs based on credit quality, I split the sample based on whether the issuance has a "high grade" or better credit rating. Bonds with a credit rating of AA- (Aa3 for Moody's ratings) or higher are considered high grade. High grade rated bonds make up 27% of long-term issuances and 17% of short-term issuances. Counties that issue high grade rated bonds are more likely to have stronger infrastructure and fiscal capacity and therefore should have less climate change risk. Therefore, a significant coefficient on climate risk for bonds rated below high grade and an insignificant coefficient for high grade bonds would suggest that the market accounts for differences in credit quality when assessing climate risk.

The results are shown in Table 7. Consistent with the market recognizing the asymmetric effect of climate risk based on credit, the coefficient on climate risk is significant only for long-term bonds that are rated below high grade. Column 1 reports that a one percent increase in climate risk is associated with a 52.7 basis point increase in the annualized costs to issue a long-term municipal bond that is rated below AA- (Aa3 for Moody's). In contrast, column 2 reports no significant relationship between climate risk and annualized issuance costs for long-term municipal bonds that are high grade rated. In columns 3 and 4 I repeat the subsample tests for short-term bonds. As expected, there is no relationship between climate risk and annualized issuance costs for short-term bonds, regardless of credit rating.

Standard and Poor's Global Ratings definition states that their rating system "takes into consideration the creditworthiness of insurers"; therefore, whether or not a bond is insured is accounted for in the rating split tests. The results are also robust to the exclusion of uninsured bonds from the sample. Additionally, the significant relationship between climate risk and issuance costs for lower rated bonds is robust to several different credit rating splits. In unreported tests I find the coefficient on climate risk is positive and significant when looking at long-term bonds rated below AAA, below AA+, or below

AA. Likewise, the climate risk coefficient is insignificant when looking at long-term bonds rated AAA, AA+ or higher, or AA or higher. These results are relevant to credit rating agencies deciding how to address climate change risk, as the findings suggest the market is able to recognize the heterogeneous effects of climate change due to credit quality.

6. Difference-in-differences around the stern review

In this section, I examine whether investor attention plays a role in the pricing of climate change risks. Investor attention has been shown to be a significant factor for stock price volatility (Andrei and Hasler, 2014), short-term stock returns (Da et al. (2011); Lou (2014)), and reactions to earnings announcements (Hirshleifer, Lim, and Teoh, 2011), among others. In the context of this paper, I expect market attention to be a key driver of whether climate risks are priced in the municipal bond market. To identify market attention on climate change, I conduct a quasi-natural experiment surrounding the release of the Stern Review, which is likely to significantly increase the market's attention towards climate change.

On October 30, 2006, economist Nicholas Stern published a report detailing the costs of damages that climate change is expected to have on the world economy. The "Stern Review" is one of the earliest and most thorough analyses of the economics of climate change and also one of the most well known. After the release of the Stern Review, it is likely that investors began paying attention to the risks climate change poses on their investments.

An increase in attention to climate change after the release of the Stern Review is evident when examining Google search volume. Figure 1 plots the quarterly average search volume for the term "climate change" for 2005 to 2007. Search volume for "climate change" spikes following the release of the Stern Review and is higher for all quarters after the release relative to the quarters before. This rise in search volume suggests an increased attention towards the risks of climate change after the Stern Review's release.

Additionally, Kass and McCarroll (2006) cite the Stern Review when making the following prediction about municipal markets:

> *"National and municipal governments around the world will be called on not only to deal with short-term floods and evacuees, but to provide emergency food, water and health care services, and to undertake agricultural restoration and large-scale urban reconstruction... Insurance companies, investors and lending institutions will, after the initial losses, begin to introduce (as some insurers already are) screening standards designed to identify climate change risks."*

Other references in the press to the Stern Review state the review raised awareness to climate change for "Wall Street investors, insurance executives, state treasurers and pension fund managers"[9] and increased voter attention towards environmentally conscious politicians.[10] The Stern Review is unlikely to change the risk profile of municipal bonds other than through increased awareness of climate change risk. Therefore, a significant increase in issuance costs for long-term climate bonds after the Stern Review would indicate that the measure of climate change is identifying climate risk and that investor attention is a key determinant of whether the market prices climate change.

In Table 8, I conduct difference-in-differences tests to examine whether increased investor attention on climate change translates into higher annualized issuance costs for climate affected bonds. I create an indicator variable equal to zero if the bond was issued prior to the release of the Stern Review, and equal to one after the Stern Review's release. The interaction variable *Ln(Climate Risk)* $\times$ *Stern* will give the marginal effect of the Stern Review on the annualized issuance costs of climate bonds relative to non-climate bonds.

The results indicate that the difference in annualized issuance costs between climate

[9] "Wall Street eyes heart of darkness: global warming" Reuters. December 2006

[10] "Climate change catching voter attention around world" Reuters. January 2007

and non-climate bonds does increase after the release of the Stern Review. Column 1 of Table 8 presents results for the difference-in-differences tests for long-term bonds. Prior to the release of the Stern Review, there is no significant relationship between climate risk and annualized issuance costs, as the coefficient on climate risk is an insignificant -15.9 basis points. However, the market begins pricing climate risk after the release of the Stern Review, with a coefficient on the interaction term of 60.7 basis points, significant at the 5% level.

To isolate the effect of market attention on the pricing of climate risk, I restrict the sample to bonds issued near the release of the Stern Review. I examine two time-frames around the Stern Review: a two year window (one year before and after the Stern Review) and a one year window (six months before and after the Stern Review). The narrower time-frames help mitigate the possibility of pre-existing trends confounding the results. Looking first at the two year window in column 2, the interaction term remains statistically significant with a coefficient of 63.3 basis points. For the one year window, the interaction term is reduced to 38.4 basis points and is statistically insignificant (t-statistic = 1.3). The similar magnitude of the coefficients for the full sample and the shortened time-frames suggests that most of the effect occurs in the year after the release of the Stern Review.[11]

In Figure 2, I further examine how the premium required for climate affected bonds changes around the Stern Review. The figure shows the difference in annualized issuance costs based on climate risk for the five quarters before and after the release of the Stern Review (which was released in the fourth quarter of 2006). The difference in annualized issuance costs is near zero in the five quarters preceding the Stern Review and grows considerably after the review is released. This difference continues to grow for several quarters after the event and is statistically significant by the third quarter of 2007,

[11]In Table A.6 of the appendix I confirm that the results of the Stern Review difference-in-differences tests are robust to the exclusion of bonds issued in New Orleans and bonds issued in unobserved coastal counties.

suggesting the market gradually incorporated the information provided by the Stern Review. The change in trends shown in Figure 2 is consistent with market attention being a driving factor in whether climate risk is priced.

In the final three columns of Table 8 I examine whether the Stern Review had any impact on short-term bond issuances. The coefficients on the interaction terms for all specifications are insignificant and greatly reduced compared to the long-term bonds. For the full sample the interaction term is an insignificant 0.1 basis points. The results in Table 8 and Figure 2 suggest that investors began paying more attention to the risks of climate change after the release of the Stern Review and recognized that these risks would be concentrated in long-term bond issuances.

7. Conclusion

The impact that climate change risk has on the municipal bond market is meaningful. I find that long-term municipal bonds are significantly affected by their level of exposure to climate change risk, whereas short-term bonds do not appear to be affected. This finding is robust to numerous term structure specifications. Additionally, the results suggest the market accounts for differences in credit quality when assessing climate risk. Finally, I find that investors appear to react to climate change news, showing that climate change is on the forefront of factors influencing investors' decisions.

For the purposes of this paper, the debate over the existence of climate change is irrelevant. Many forms of investment risk go unrealized, yet investors require a premium for the uncertainty that accompanies those risks. The findings in this paper suggest that investors account for the increased uncertainty as to whether they will see a return of capital from municipal bonds issued in counties with higher climate change risk, regardless of whether those counties actually will be affected by climate change.

The evidence found in this study has important implications for the counties most likely to be affected by climate change. Because climate change risk is causing counties to be negatively affected today through higher debt issuance costs, these counties should be proactive in reducing the amount of damage that sea level rise is likely to cause to their municipalities. The findings in this paper provide evidence that investors are aware of climate change risks to their assets and are taking these risks into account when investing. The ability of the market to recognize differences in climate risk based on credit quality is an important factor for whether credit rating agencies decide to downgrade these municipalities' bonds.

Though there has been prior research showing that investors account for reputation and regulation risk when investing in companies that contribute to climate change, this paper is the first to document that investors account for the risk that climate change poses on fixed income assets in their portfolios. The results of this paper could potentially motivate counties to take steps towards preparing themselves for the potential damages of sea level rise, helping them to avoid climate change's "inconvenient cost".

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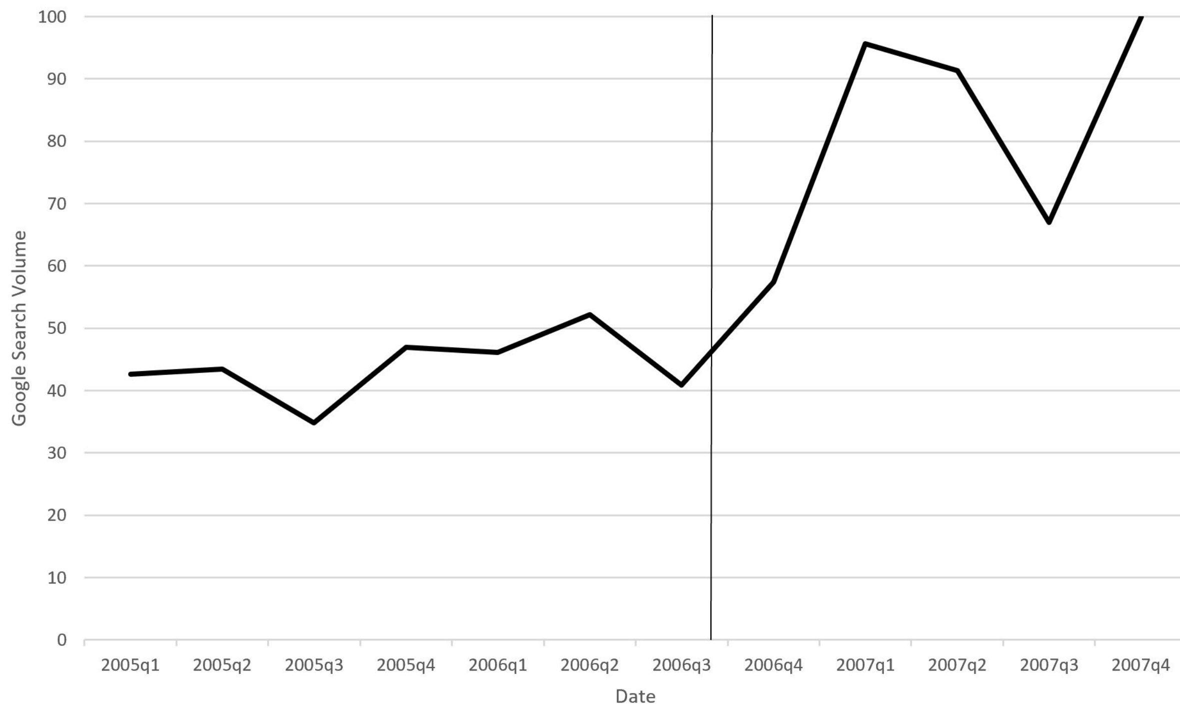

Figure 1
Google Search Volume for "Climate Change" around the Stern Review
This figure presents the quarterly average search frequency for the term "climate change" using Google Trends. The search volume is scaled so that 100 represents the peak search volume for the time-frame of 2005 to 2007. The vertical line indicates the release date of the Stern Review, October 30, 2006.

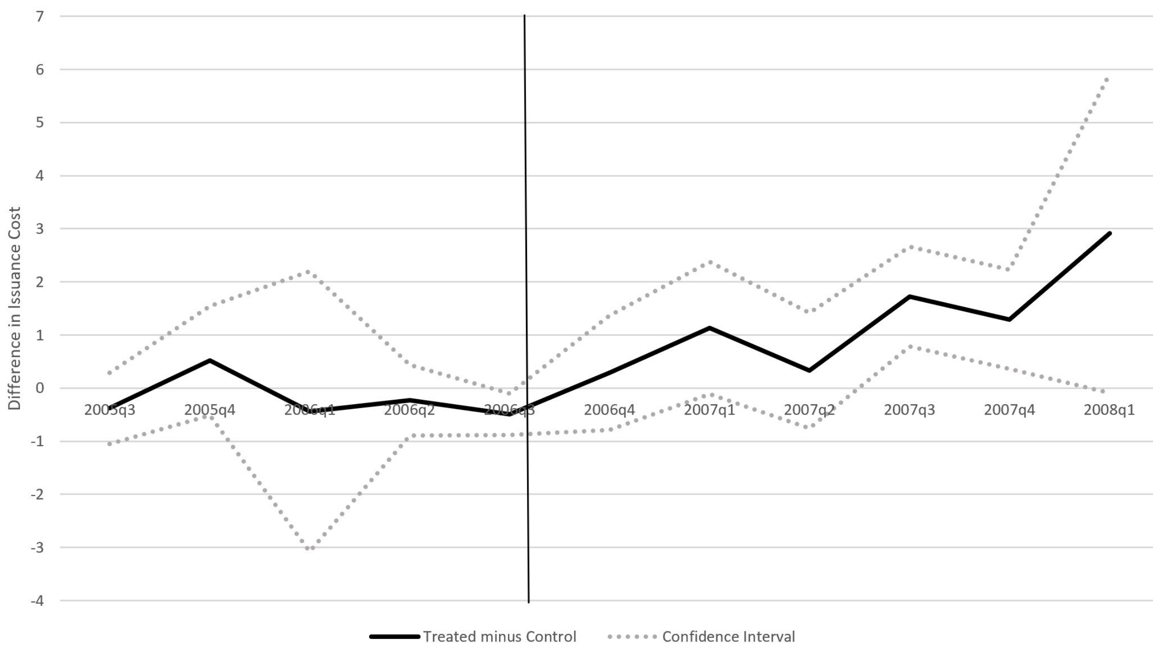

Figure 2
Climate Risk & Issuances Costs around the Stern Review
This figure presents the difference in municipal bond annualized issuance costs for counties with climate risk relative to counties without climate risk around the release of the Stern Review. The coefficients are based on a regression of total annualized issuance cost on the interaction of climate risk and year-quarter time dummies. The regression also includes the full set of controls used in the main specification in Table 3. 90% confidence intervals based on standard errors clustered by county of issuance are shown using dotted lines. Coefficients for the five quarters before and after the event are presented. The vertical line indicates the release date of the Stern Review, October 30, 2006.

Table 1
Counties with Climate Change Risk

This table ranks cities by their exposure to climate change risk by expected mean annual loss as a percentage of a city's GDP. The mean annual loss is the optimistic bound calculated assuming a 40cm rise in sea level and that cities attempt to adapt to the rise in sea level. Cities and counties that are grouped together are assigned the same climate risk. The estimates in this table are from Hallegatte et al. (2013). All counties not included in this table are assigned a climate risk of zero.

City	County	Mean Annual Loss (MM$)	Climate Risk
New Orleans, LA	Orleans	1940	1.479%
Miami, FL	Miami Dade	2964	0.420%
Tampa/St. Petersburg, FL	Hillsborough, Pinellas	948	0.324%
Virginia Beach, VA	Virginia Beach	328	0.173%
Boston, MA	Suffolk	849	0.149%
Baltimore, MD	Baltimore	299	0.104%
LA/Long Beach/Santa Ana, CA	Los Angeles, Orange	217	0.097%
New York, NY/ Newark,NJ	Bronx, Kings, New York, Queens, Richmond, Essex	2159	0.089%
Providence, RI	Providence	135	0.083%
Philadelphia, PA	Philadelphia	309	0.044%
San Francisco/Oakland, CA	San Francisco, Alameda	185	0.042%
Houston, TX	Walker, Montgomery, Liberty, Waller, Austin, Harris, Chambers, Colorado, Wharton, Fort Bend, Galveston, Brazoria, Matagorda	214	0.038%
Seattle, WA	King	90	0.023%
Washington D.C.	Washington	91	0.016%
San Diego, CA	San Diego	14	0.004%
Portland, OR	Multnomah	4	0.002%
San Jose, CA	Santa Clara	2	0.001%

Table 2
New Issue Municipal Bond Data

This table reports descriptive statistics for the sample of bonds acquired from Bloomberg, covering bonds that were issued from January 2004 through March 2017. All bonds in this sample have issue sizes of $1MM or greater and are rated by either S&P or Moody's. Panel A reports variables including the difference between the price underwriters paid for the issue and what price they sold the issue to the market (Gross Spread, winsorized at 3% and 97%), the yield the bond was issued at (winsorized at 3% and 97%), the total annualized cost of issuance (annualized gross spread plus yield), the total size of the issue (Issue Size), the bond's maturity not considering options of the issue (Max Maturity), dummy variables equaling one if the bond is callable, insured, sinkable, GO backed, pre-refunded, or competitively issued, a numerical scale of credit rating (Rating), and dummy variables identifying whether the bond is exempt from federal and state taxes. AMT identifies bonds that are subject to the alternative minimum tax. CUSIPS/Issue reports how many bonds are packaged in each issue and # of deals an Underwriter has issued in the sample. Panel B breaks down the statistics by the time range the bond was issued and by rating. Each row presents the mean value for each variable. N denotes the number of observations for each category that have non-missing values of total annualized issuance cost.

Panel A: Descriptive Statistics by Climate Risk

	Climate Bonds				Non-Climate Bonds			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	N	Mean	Median	SD	N	Mean	Median	SD
Total Annualized Cost (%)	40161	3.03	2.93	1.52	210695	2.95	2.85	2.17
Gross Spread (%)	41766	0.54	0.49	0.30	217113	0.60	0.53	0.33
Yield (%)	49309	3.02	3.00	1.42	269820	2.91	2.85	1.37
Issue Size (MM$)	50914	13.40	4.36	33.40	276238	8.00	2.62	22.20
Max Maturity (Years)	50914	14.63	13.98	8.65	276238	13.57	12.54	8.10
Callable	50914	0.61	1.00	0.49	276238	0.60	1.00	0.49
Insurance	50914	0.15	0.00	0.36	276238	0.16	0.00	0.37
Rating	50914	3.25	3.00	1.90	276238	3.22	3.00	1.91
Sinkable	50914	0.18	0.00	0.39	276238	0.19	0.00	0.39
GO	50914	0.40	0.00	0.49	276238	0.49	0.00	0.50
Pre-Refunded	50914	0.06	0.00	0.24	276238	0.07	0.00	0.25
Competitive	50914	0.23	0.00	0.42	276238	0.28	0.00	0.45
AMT	50914	0.04	0.00	0.20	276238	0.03	0.00	0.17
Fed Exempt	50914	0.85	1.00	0.36	276238	0.81	1.00	0.39
State Exempt	50914	0.77	1.00	0.42	276238	0.75	1.00	0.43
CUSIPS/Issue	50914	12.77	10.00	10.38	276238	10.81	9.00	8.83
# Underwriter Deals (M)	50914	16.82	17.95	10.75	276238	14.53	15.92	10.62

Table 2 - Continued from Previous Page

Panel B: Descriptive Statistics by Categories

	(1) Total Cost	(2) Yield	(3) Spread	(4) % Climate	(5) N
Max Maturity ≥ 25	4.66	4.58	0.67	19.78%	19527
Max Maturity < 25	2.82	2.77	0.59	15.10%	231280
Rating = 1	2.62	2.63	0.52	14.53%	46544
Rating = 2, 3, or 4	2.92	2.90	0.61	16.45%	155131
Rating = 5, 6, or 7	3.27	3.31	0.62	12.48%	39869
Rating ≥ 8	4.20	4.09	0.91	18.70%	9312

Table 3
Effect of Climate Risk on Municipal Bond Annualized Issuance Costs

This table presents the results of ordinary least squares regressions of equation (1). The variable of interest is Climate Risk, defined in Table 1. The Long-Term sample contains bond issuances with a maximum maturity of 25 years or more. The Short-Term sample contains bond issuances with a maximum maturity of less than 25 years. The dependent variable in Panel A is the total annualized issuance cost of a municipal bond. In Panel B, the dependent variable is the initial yield of the bond. Gross spread is the dependent variable in Panel C. t-statistics, based on errors clustered by county, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Panel A: Total Annualized Issuance Cost for Long-Term and Short-Term Bonds

		Long-Term			Short-Term	
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:			Total Annualized Cost			
Climate Risk	0.333***	0.234*		0.092	0.077	
	(2.932)	(1.854)		(1.525)	(1.544)	
Ln(Climate Risk)			0.339**			0.093
			(2.085)			(1.117)
Ln(Size)	-0.080***	-0.070***	-0.070***	-0.008	0.001	0.001
	(-7.863)	(-7.010)	(-7.028)	(-1.262)	(0.178)	(0.176)
Ln(Maturity)	0.813***	0.818***	0.818***	0.951***	0.667***	0.667***
	(5.666)	(6.317)	(6.307)	(21.872)	(8.230)	(8.230)
Rating	0.106***	0.116***	0.116***	0.139***	0.126***	0.126***
	(16.950)	(17.215)	(17.240)	(17.034)	(13.848)	(13.851)
Callable		0.007	0.008		0.532***	0.532***
		(0.074)	(0.078)		(6.800)	(6.800)
Insurance		0.023	0.023		0.235***	0.235***
		(0.881)	(0.880)		(12.754)	(12.764)
Sinkable		0.056	0.057		0.284***	0.284***
		(0.735)	(0.738)		(21.369)	(21.362)
GO		0.006	0.007		-0.083***	-0.083***
		(0.180)	(0.194)		(-3.800)	(-3.799)
Pre-Refunded		0.105***	0.105***		0.039**	0.039**
		(4.500)	(4.498)		(1.969)	(1.971)
Competitive		-0.089	-0.089		-0.055***	-0.055***
		(-1.467)	(-1.465)		(-5.380)	(-5.368)
Fed Exempt		-0.476***	-0.476***		-0.313***	-0.313***
		(-11.091)	(-11.092)		(-9.647)	(-9.649)
State Exempt		0.028	0.027		-0.052*	-0.052*
		(0.451)	(0.431)		(-1.746)	(-1.746)
AMT		-0.248***	-0.248***		0.071	0.071
		(-4.464)	(-4.463)		(1.568)	(1.567)
Ln(CUSIPS/Issue)		0.171***	0.170***		-0.027*	-0.027*
		(6.309)	(6.291)		(-1.954)	(-1.953)
Ln(Underwriter Deals)		-0.000	-0.000		0.000	0.000
		(-0.032)	(-0.028)		(0.005)	(0.009)
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,527	19,527	19,527	231,280	231,280	231,280
R-squared	0.284	0.295	0.295	0.268	0.284	0.284

Table 3 - Continued from Previous Page

Panel B: Yield for Long-Term and Short-Term Bonds

	Long-Term		Short-Term	
	(1)	(2)	(3)	(4)
Dependent Variable:	Yield	Yield	Yield	Yield
Climate Risk	0.161**		0.070	
	(2.219)		(1.462)	
Ln(Climate Risk)		0.203*		0.079
		(1.816)		(1.008)
Controls	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes
Observations	27,355	27,355	291,746	291,746
R-squared	0.503	0.503	0.839	0.839

Panel C: Gross Spread for Long-Term and Short-Term Bonds

	Long-Term		Short-Term	
	(1)	(2)	(3)	(4)
Dependent Variable:	Spread	Spread	Spread	Spread
Climate Risk	0.108**		-0.004	
	(1.972)		(-0.072)	
Ln(Climate Risk)		0.152**		0.019
		(2.188)		(0.222)
Controls	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes
Observations	24,514	24,514	234,321	234,321
R-squared	0.368	0.369	0.326	0.326

Table 4

Effect of Climate Risk on Municipal Bond Annualized Issuance Costs: Robustness

This table presents robustness checks for the regressions reported in Table 3. Columns 1, 2, 5, and 6 drop all observations for bonds that were issued in Orleans Parish. Columns 3, 4, 7, and 8 also drop all observations for bonds issued in coastal counties that are not assigned a climate risk in Hallegatte et al. (2013). The dependent variable in Panel A is the total annualized issuance cost of a municipal bond. In Panel B, the dependent variable is the initial yield of the bond. Gross spread is the dependent variable in Panel C. t-statistics, based on errors clustered by county, are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Panel A: Total Annualized Issuance Cost for Long-Term and Short-Term Bonds

	Long-Term				Short-Term			
	No New Orleans		No Unobs. Coastal		No New Orleans		No Unobs. Coastal	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable:	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost
Climate Risk	0.379**		0.366**		0.035		-0.035	
	(2.316)		(2.023)		(0.339)		(-0.234)	
Ln(Climate Risk)		0.441**		0.414*		0.040		-0.046
		(2.250)		(1.889)		(0.324)		(-0.269)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,512	19,512	16,749	16,749	231,030	231,030	196,330	196,330
R-squared	0.295	0.295	0.274	0.274	0.283	0.283	0.252	0.252

Table 4 - Continued from Previous Page

Panel B: Yield for Long-Term and Short-Term Bonds

	Long-Term				Short-Term			
	No New Orleans		No Unobs. Coastal		No New Orleans		No Unobs. Coastal	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable:	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield
Climate Risk	0.249**		0.222*		0.020		-0.067	
	(1.953)		(1.645)		(0.200)		(-0.463)	
Ln(Climate Risk)		0.285*		0.241		0.019		-0.084
		(1.906)		(1.503)		(0.167)		(-0.513)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27,334	27,334	23,422	23,422	291,479	291,479	245,617	245,617
R-squared	0.510	0.510	0.516	0.516	0.835	0.835	0.833	0.833

Panel C: Gross Spread for Long-Term and Short-Term Bonds

	Long-Term				Short-Term			
	No New Orleans		No Unobs. Coastal		No New Orleans		No Unobs. Coastal	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable:	Spread	Spread	Spread	Spread	Spread	Spread	Spread	Spread
Climate Risk	0.192**		0.194*		0.119		0.147	
	(2.412)		(1.940)		(1.131)		(1.522)	
Ln(Climate Risk)		0.220**		0.222*		0.139		0.170
		(2.405)		(1.946)		(1.131)		(1.511)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,496	24,496	21,111	21,111	234,067	234,067	199,026	199,026
R-squared	0.347	0.347	0.353	0.353	0.312	0.312	0.312	0.312

Table 5
Maturity

This table reports the results of ordinary least squares regressions of equation (1) for varying term structure specifications. The variable of interest is the log of Climate Risk, defined in Table 1. The dependent variable is the total annualized issuance cost of a municipal bond. Panel A presents results for long-term maturity specifications. Panel B reports results for short-term maturity specifications. t-statistics, based on errors clustered by county, are in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Panel A: Long-Term Specifications

	(1)	(2)	(3)	(4)	(5)
Issue Maturity:	$\geq$ 20 Years	$\geq$ 30 Years	$\geq$ 2036	$\geq$ 2041	$\geq$ 2046
Ln(Climate Risk)	0.198*	0.656**	0.205*	0.489*	1.540***
	(1.876)	(2.171)	(1.705)	(1.714)	(2.967)
Controls	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	46,191	6,665	25,307	8,495	2,095
R-squared	0.368	0.232	0.339	0.222	0.160

Panel B: Short-Term Specifications

	(1)	(2)	(3)	(4)	(5)
Issue Maturity:	< 20 Years	< 30 Years	< 2036	< 2041	< 2046
Ln(Climate Risk)	0.069	0.108	0.098	0.113	0.113
	(0.789)	(1.272)	(1.171)	(1.353)	(1.347)
Controls	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	204,650	244,091	225,512	242,273	248,642
R-squared	0.227	0.310	0.293	0.320	0.322

Table 6
Placebo Tests

This table presents regression results of equation (1) for various long-term specifications where climate risk is assigned to placebo counties. In Panel A, placebo counties are identified as the counties closest to the climate counties but not located on the coast. In Panel B, the placebo counties are assigned using nearest neighbor matching on the propensity to be a climate affected county. Neighbors are matched based on the size of issuances, the number of CUSIPs per issue, the total number of issues by the county in the sample, and credit rating. I require all matched counties to be in non-coastal states. The dependent variable is the total annualized cost to issue a municipal bond. The variable of interest is the log of Climate Risk, defined in Table 1. t-statistics, based on errors clustered by county, are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Panel A: Geographic Matching

	(1)	(2)	(3)	(4)	(5)	(6)
Issue Maturity:	$\geq$ 20 Years	$\geq$ 25 Years	$\geq$ 30 Years	$\geq$ 2036	$\geq$ 2041	$\geq$ 2046
Ln(Climate Risk)	-0.007	0.135	0.223	0.111	0.012	0.045
	(-0.058)	(0.738)	(0.728)	(0.825)	(0.092)	(0.107)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	46,191	19,527	6,665	25,307	8,495	2,095
R-squared	0.606	0.578	0.563	0.670	0.630	0.702

Panel B: Nearest Neighbor Matching

	(1)	(2)	(3)	(4)	(5)	(6)
Issue Maturity:	$\geq$ 20 Years	$\geq$ 25 Years	$\geq$ 30 Years	$\geq$ 2036	$\geq$ 2041	$\geq$ 2046
Ln(Climate Risk)	-0.061	-0.127	-0.294	-0.057	-0.151	-0.439
	(-1.083)	(-1.493)	(-1.336)	(-0.663)	(-1.197)	(-1.637)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	46,191	19,527	6,665	25,307	8,495	2,095
R-squared	0.606	0.578	0.563	0.670	0.630	0.703

Table 7
Credit Rating Split

This table reports the results of ordinary least squares regressions of equation (1) for different credit rating specifications. The variable of interest is the log of Climate Risk, defined in Table 1. Bonds included in the "<AA-" sample have a credit rating at issuance below AA- (or below Moody's Aa3 if they are not rated by S&P). Bonds included in the "≥AA-" sample have a credit rating of AA- or higher (or Moody's Aa3 or higher if they are not rated by S&P). The Long-Term sample contains bond issuances with a maximum maturity of 25 years or more. The Short-Term sample contains bond issuances with a maximum maturity of less than 25 years. The dependent variable is the total annualized issuance cost of a municipal bond. t-statistics, based on errors clustered by county, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

	Long-Term		Short-Term	
	(1)	(2)	(3)	(4)
Credit Rating:	$<$ AA-	$\geq$ AA-	$<$ AA-	$\geq$ AA-
Ln(Climate Risk)	0.527**	0.141	0.107	0.091
	(2.041)	(0.686)	(0.878)	(0.634)
Controls	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes
Observations	5,339	14,095	43,714	187,529
R-squared	0.609	0.238	0.090	0.724

Table 8
Difference-In-Differences of Issuance Costs around the Stern Review

This table presents difference-in-difference estimates for the total annualized cost to issue a municipal bond before and after the Stern Review was released. Stern takes a value of one if the bond was issued after the Stern Review was released, zero otherwise. The Stern Review was released on October 30, 2006. The Long-Term sample contains bond issuances with a maximum maturity of 25 years or more. The Short-Term sample contains bond issuances with a maximum maturity of less than 25 years. Columns 1 and 4 contain bond issuances for the entire sample. Columns 2 and 5 restrict the sample to bonds issued within a two year window (one year before until one year after) around the Stern Review. Columns 3 and 6 restrict the sample to bonds issued within a one year window (six months before until six months after) around the Stern Review. t-statistics, based on errors clustered by county, are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

	Long-Term			Short-Term		
	(1)	(2)	(3)	(4)	(5)	(6)
Time Frame:	Full Sample	Two Years	One Year	Full Sample	Two Years	One Year
Ln(Climate Risk)	-0.159	-0.242*	-0.205	0.091	0.533	-0.064
	(-0.727)	(-1.708)	(-1.254)	(0.228)	(1.163)	(-0.243)
Ln(Climate Risk) x Stern	0.607**	0.633**	0.384	0.001	-0.554	-0.138
	(2.429)	(2.167)	(1.295)	(0.002)	(-1.250)	(-0.487)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,561	5,000	2,406	231,295	8,579	4,142
R-squared	0.297	0.220	0.248	0.284	0.124	0.156

Appendix

Table A.1
Maturity: Robustness

This table presents robustness checks for the regressions reported in Table 5. Panel A drops all observations for bonds that were issued in Orleans Parish. Panel B also drops all observations for bonds issued in coastal counties that are not assigned a climate risk in Hallegatte et al. (2013). The dependent variable is the total annualized issuance cost of a municipal bond. t-statistics, based on errors clustered by county, are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Panel A: No New Orleans

	Long-Term					Short-Term				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Issue Maturity:	$\geq$ 20 Years	$\geq$ 30 Years	$\geq$ 2036	$\geq$ 2041	$\geq$ 2046	$<$ 20 Years	$<$ 30 Years	$<$ 2036	$<$ 2041	$<$ 2046
Ln(Climate Risk)	0.164	0.862**	0.208	0.707*	2.091**	0.011	0.064	0.058	0.077	0.078
	(1.161)	(2.583)	(1.158)	(1.646)	(2.590)	(0.085)	(0.503)	(0.457)	(0.606)	(0.613)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	46,155	6,659	25,281	8,484	2,092	204,421	243,832	225,273	242,019	248,381
R-squared	0.368	0.232	0.339	0.222	0.160	0.227	0.309	0.293	0.320	0.322

Table A.1 - Continued from Previous Page

Panel B: No Unobserved Coastal

	Long-Term					Short-Term				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Issue Maturity:	$\geq$ 20 Years	$\geq$ 30 Years	$\geq$ 2036	$\geq$ 2041	$\geq$ 2046	$<$ 20 Years	$<$ 30 Years	$<$ 2036	$<$ 2041	$<$ 2046
Ln(Climate Risk)	0.110	0.849**	0.205	1.078**	3.028***	-0.055	-0.034	-0.039	-0.027	-0.031
	(0.651)	(2.230)	(0.957)	(2.289)	(2.853)	(-0.309)	(-0.192)	(-0.218)	(-0.155)	(-0.177)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	39,592	5,735	21,776	7,267	1,828	173,518	207,304	191,320	205,774	211,198
R-squared	0.348	0.219	0.314	0.208	0.146	0.200	0.277	0.262	0.287	0.289

Table A.2

Maturity: Yield and Gross Spread

This table presents results for yield and gross spread separately for the regressions reported in Table 5. Panel A shows results for the long-term specifications. Panel B shows results for short-term specifications. Columns 1 through 5 report results for yield. Columns 6 through 10 report results for gross spread. t-statistics, based on errors clustered by county, are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Panel A: Long-Term Specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Issue Maturity:	$\geq$ 20 Years	$\geq$ 30 Years	$\geq$ 2036	$\geq$ 2041	$\geq$ 2046	$\geq$ 20 Years	$\geq$ 30 Years	$\geq$ 2036	$\geq$ 2041	$\geq$ 2046
Dependent Variable:	Yield	Yield	Yield	Yield	Yield	Spread	Spread	Spread	Spread	Spread
Ln(Climate Risk)	0.231**	0.457	0.205*	0.288	0.663***	0.134*	0.203*	0.170*	0.178	0.217
	(2.215)	(1.632)	(1.640)	(1.316)	(2.805)	(1.785)	(1.691)	(1.878)	(1.258)	(0.799)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	65,248	9,108	31,107	9,998	2,458	52,623	9,430	29,285	9,954	2,599
R-squared	0.547	0.496	0.630	0.608	0.685	0.339	0.371	0.383	0.446	0.514

Panel B: Short-Term Specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Issue Maturity:	< 20 Years	< 30 Years	< 2036	< 2041	< 2046	< 20 Years	< 30 Years	< 2036	< 2041	< 2046
Dependent Variable:	Yield	Yield	Yield	Yield	Yield	Spread	Spread	Spread	Spread	Spread
Ln(Climate Risk)	0.061	0.087	0.078	0.094	0.093	0.021	0.040	0.023	0.037	0.041
	(0.754)	(1.024)	(0.969)	(1.159)	(1.149)	(0.224)	(0.449)	(0.257)	(0.420)	(0.470)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	253,876	309,946	287,994	309,040	316,559	206,242	249,357	229,563	248,841	256,166
R-squared	0.817	0.837	0.841	0.841	0.838	0.301	0.314	0.305	0.309	0.311

Table A.3
Placebo Tests: Yield and Gross Spread

This table presents results for the regressions shown in Table 6 with yield and gross spread reported separately. Panel A shows results for various long-term specifications for the geographic matching placebo tests. Panel B shows results for various long-term specifications for the nearest neighbor matching placebo tests. The results for yield are reported in columns 1 through 6 and the results for gross spread are reported in columns 7 through 12. t-statistics, based on errors clustered by county, are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Panel A: Geographic Matching

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Issue Maturity:	$\geq$ 20Yr	$\geq$ 25Yr	$\geq$ 30Yr	$\geq$2036	$\geq$2041	$\geq$2046	$\geq$ 20Yr	$\geq$ 25Yr	$\geq$ 30Yr	$\geq$ 2036	$\geq$ 2041	$\geq$ 2046
Dependent Var:	Yield	Yield	Yield	Yield	Yield	Yield	Spread	Spread	Spread	Spread	Spread	Spread
Ln(Climate Risk)	0.021	0.115	0.281	0.118	-0.015	-0.113	-0.044	-0.059	-0.047	-0.040	0.064	0.042
	(0.188)	(0.574)	(0.843)	(0.776)	(-0.111)	(-0.278)	(-1.381)	(-1.309)	(-0.614)	(-1.354)	(0.406)	(0.488)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	65,248	27,355	9,108	31,107	9,998	2,458	52,623	24,514	9,430	29,285	9,954	2,599
R-squared	0.553	0.503	0.479	0.630	0.595	0.667	0.358	0.368	0.400	0.403	0.358	0.545

Panel B: Nearest Neighbor Matching

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Issue Maturity:	$\geq$ 20Yr	$\geq$ 25Yr	$\geq$ 30Yr	$\geq$2036	$\geq$2041	$\geq$2046	$\geq$ 20Yr	$\geq$ 25Yr	$\geq$ 30Yr	$\geq$ 2036	$\geq$ 2041	$\geq$ 2046
Dependent Var:	Yield	Yield	Yield	Yield	Yield	Yield	Spread	Spread	Spread	Spread	Spread	Spread
Ln(Climate Risk)	-0.027	-0.048	-0.189	0.029	0.049	-0.326	-0.106	-0.191*	-0.185**	-0.181	-0.144	-0.004
	(-0.422)	(-0.476)	(-1.153)	(0.335)	(0.381)	(-1.322)	(-1.628)	(-1.768)	(-2.478)	(-1.595)	(-1.438)	(-0.036)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	65,248	27,355	9,108	31,107	9,998	2,458	52,623	24,514	9,430	33,246	9,954	2,599
R-squared	0.553	0.503	0.479	0.630	0.595	0.667	0.174	0.267	0.261	0.276	0.358	0.545

Table A.4
Credit Rating Split: Robustness

This table presents robustness checks for the regressions reported in Table 7. Panel A drops all observations for bonds that were issued in Orleans Parish. Panel B also drops all observations for bonds issued in coastal counties that are not assigned a climate risk in Hallegatte et al. (2013). The dependent variable is the total annualized issuance cost of a municipal bond. t-statistics, based on errors clustered by county, are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Panel A: No New Orleans

	Long-Term		Short-Term	
	(1)	(2)	(3)	(4)
Credit Rating:	$<$ AA-	$\geq$ AA-	$<$ AA-	$\geq$ AA-
Ln(Climate Risk)	0.738	0.136	0.140	-0.007
	(1.585)	(0.594)	(0.607)	(-0.038)
Controls	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes
Observations	5,327	14,092	43,570	187,423
R-squared	0.609	0.238	0.090	0.724

Panel B: No Unobserved Coastal

	Long-Term		Short-Term	
	(1)	(2)	(3)	(4)
Credit Rating:	$<$ AA-	$\geq$ AA-	$<$ AA-	$\geq$ AA-
Ln(Climate Risk)	0.747*	0.189	0.352	-0.135
	(1.937)	(0.707)	(1.230)	(-0.591)
Controls	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes
Observations	4,583	12,078	37,185	159,107
R-squared	0.628	0.215	0.079	0.711

Table A.5

Credit Rating Split: Yield and Gross Spread

This table presents results for the regressions shown in Table 7 with yield and gross spread reported separately. Panel A reports results for the credit rating splits with yield as the dependent variable. Gross spread is the dependent variable in Panel B. t-statistics, based on errors clustered by county, are in parentheses.

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

Panel A: Yield

	Long-Term		Short-Term	
	(1)	(2)	(3)	(4)
Credit Rating:	< AA-	≥ AA-	< AA-	≥ AA-
Ln(Climate Risk)	0.782***	0.023	0.154	0.057
	(2.700)	(0.129)	(1.505)	(0.420)
Controls	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes
Observations	7,036	20,231	50,355	241,357
R-squared	0.551	0.520	0.809	0.846

Panel B: Gross Spread

	Long-Term		Short-Term	
	(1)	(2)	(3)	(4)
Credit Rating:	< AA-	≥ AA-	< AA-	≥ AA-
Ln(Climate Risk)	0.188*	0.116	-0.075	0.132
	(1.762)	(1.288)	(-1.003)	(1.183)
Controls	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes
Observations	6,927	17,508	54,426	189,702
R-squared	0.461	0.349	0.365	0.306

Table A.6

Difference-in-Differences of Annualized Issuance Costs around the Stern Review: Robustness

This table presents robustness checks for the regressions reported in Table 8. Panel A drops all observations for bonds that were issued in Orleans Parish. Panel B also drops all observations for bonds issued in coastal counties that are not assigned a climate risk in Hallegatte et al. (2013). t-statistics, based on errors clustered by county, are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Panel A: No New Orleans

	Long-Term			Short-Term		
	(1)	(2)	(3)	(4)	(5)	(6)
Time Frame:	Full Sample	Two Years	One Year	Full Sample	Two Years	One Year
Ln(Climate Risk)	-0.090	-0.202	-0.093	-0.313	-0.031	-0.064
	(-0.344)	(-1.022)	(-0.332)	(-1.000)	(-0.190)	(-0.243)
Ln(Climate Risk) x Stern	0.663**	0.596*	0.285	0.360	-0.008	-0.138
	(2.081)	(1.938)	(0.814)	(1.118)	(-0.048)	(-0.487)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,546	4,998	2,404	231,045	8,577	4,142
R-squared	0.297	0.220	0.248	0.284	0.124	0.156

Panel B: No Unobserved Coastal

	Long-Term			Short-Term		
	(1)	(2)	(3)	(4)	(5)	(6)
Time Frame:	Full Sample	Two Years	One Year	Full Sample	One Year	Two Years
Ln(Climate Risk)	-0.244	-0.289	-0.267	-0.612	-0.187	-0.128
	(-0.897)	(-1.287)	(-0.997)	(-1.413)	(-0.491)	(-0.533)
Ln(Climate Risk) x Stern	0.815**	0.536*	0.316	0.577	0.084	0.080
	(2.097)	(1.823)	(0.887)	(1.321)	(0.264)	(0.392)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,783	4,233	2,031	196,344	3,505	7,281
R-squared	0.276	0.229	0.260	0.252	0.156	0.127

Table A.7

Difference-in-Differences of Yield and Gross Spread around the Stern Review

This table presents results for the regressions shown in Table 8 with yield and gross spread reported separately. Yield is the dependent variable in Panel A. Gross Spread is the dependent variable in Panel B. t-statistics, based on errors clustered by county, are in parentheses.

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

Panel A: Yield

	Long-Term			Short-Term		
	(1)	(2)	(3)	(4)	(5)	(6)
Time Frame:	Full Sample	Two Years	One Year	Full Sample	Two Years	One Year
Ln(Climate Risk)	0.078	-0.222	-0.179	0.001	0.298	-0.053
	(0.630)	(-1.640)	(-1.108)	(0.003)	(0.686)	(-0.211)
Ln(Climate Risk) x Stern	0.293*	0.754**	0.326	0.087	-0.189	-0.159
	(1.698)	(2.424)	(1.084)	(0.346)	(-0.536)	(-0.575)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27,379	7,033	2,406	291,750	12,795	4,142
R-squared	0.512	0.168	0.266	0.835	0.107	0.155

Panel B: Gross Spread

	Long-Term			Short-Term		
	(1)	(2)	(3)	(4)	(5)	(6)
Time Frame:	Full Sample	Two Years	One Year	Full Sample	One Year	Two Years
Ln(Climate Risk)	-0.002	-0.025	-0.152	-0.088	0.010	0.000
	(-0.019)	(-0.196)	(-1.274)	(-0.812)	(0.097)	(0.001)
Ln(Climate Risk) x Stern	0.224**	0.269	0.289*	0.128	0.205	0.217
	(2.074)	(1.404)	(1.865)	(0.884)	(0.915)	(0.550)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,542	5,659	3,388	231,295	9,727	4,142
R-squared	0.348	0.231	0.282	0.313	0.294	0.295