# The U.S. municipal bond market does not price in physical climate risk ... yet

**June 2022**

## Executive summary

As concern about climate risk disclosure grows, an analysis of ~800,000 U.S. municipal bonds representing over $2.5T in outstanding debt shows no evidence that it is being systematically priced in.

This also holds true for bonds issued between 2017 to 2021, an era of heighted climate awareness in financial markets. Testing the premise that investors might perceive climate change only to be a material risk in the distant future, we limited the analysis to outstanding long-dated (20+ year maturity) bonds and found the same result. This stands in slight contrast to two recent studies that suggest investors may demand very modest premiums for bonds exposed to dramatic long-term sea level rise.

The lack of clear climate risk pricing is troubling given that event-based climate risk is correlated with discounts in both property value appreciation and population growth over the past decade -- the pillars of municipal market tax revenue and stability. This creates a potential "frog in a boiling pot of water" situation, where systemic risk is significantly underestimated, and the heat will at least turn up gradually, and maybe abruptly. This is especially true in the current market, where the treasury rate is historically low and there is more investor demand for bonds than there is supply, compressing yield spreads.

The municipal debt ecosystem can finance many aspects of climate adaptation in the U.S. The market's stakeholders ultimately have an incentive to do so. Our goal is to provide key participants with insight into how climate risk may affect their assets and tools to evaluate the financial and social cost-benefit tradeoffs of specific, local climate resilience investments.

All data and charts used in this report are based on data obtained by ICE Data Services and available via its product offerings, unless otherwise cited.

## Introduction

Climate risk has only surfaced to the consciousness of the U.S. municipal debt market in the last couple of decades. ICE Climate Risk and a handful of other climate-related data products are relatively new to the municipal market. Clients have only been using ICE Climate Risk since early 2020. A quickly growing number of municipal debt asset managers, bond insurers, and rating agencies are now employing ICE's climate risk data on an operational and strategic basis. Yet given the supply constraint dynamics of the market (generally, there is more money to be invested than there is debt issuance to buy) we find no evidence that ***physical climate risk is not priced into the cost for issuers to borrow capital.***

## Analysis

To test that hypothesis, we analyzed the yield of ~800,000 bonds (CUSIP9's) issued from 2006 to 2021 covering ~$2.5T of the current ~$3.9T in outstanding debt in the market. We first used a random forest statistical model to estimate the expected yield of all the CUSIP9's based on a variety of controls as well as external variables -- but without using climate risk as an input. The basic controls include issuance year (as a proxy interest rate), original principal balance, bond duration, obligor type (e.g., county, school district, hospital, dirt deal, state, etc.), and security type (e.g., general obligation or revenue bond).

The model works well, explaining the majority (~84%) of the variance in yield in out-of-sample tests (i.e., with bonds the model has not yet seen). Also, fully aware that the background socioeconomic profiles of issuers are given consideration in credit ratings, credit desk analysis, and consequently yield spread, we also input ICE's Social Impact Scores into the model. In particular, we input all 7 of its subscores: the Persistent Health Obstacles Score, the Nonwhite/Minority Score, the Housing Unaffordability Score, the At-Risk Employment Score, the Low Educational Attainment Score, the Low Affluence Score, and the Poverty Concentration Score. All range from 0-100 where higher scores indicate more need for resources related to their themes; as they increase, a reasonable hypothesis would be that so does credit risk as conventionally and historically framed (more on this topic in a near term future article).

We then define a "Yield-to-Expectation Ratio (YER)" as the ratio of the actual original yield over the expected yield estimated from the statistical model. If climate risk has indeed been priced into the market, there would be a broad, positive correlation between our core measure of acute physical climate risk -- the risQ Scores, which we have shown to correlate to adverse outcomes in the pillars underlying the municipal market, including property value, population change, and mortgage delinquency -- and the YER. To test this in a robust statistical way, we perform a permutation test on the pairing of issuers' YER and their risQ Scores.

The permutation test works by assigning a new, randomly selected risQ Score to each issuer. This random assignment breaks any potential real correlation between the risQ Score and issuers' YER. We repeat this random assignment 10,000 times, obtaining a Monte Carlo distribution of what the data would look like if there was no correlation between climate risk and residual yield. We then compare the original, real correlation with this "no correlation" distribution.

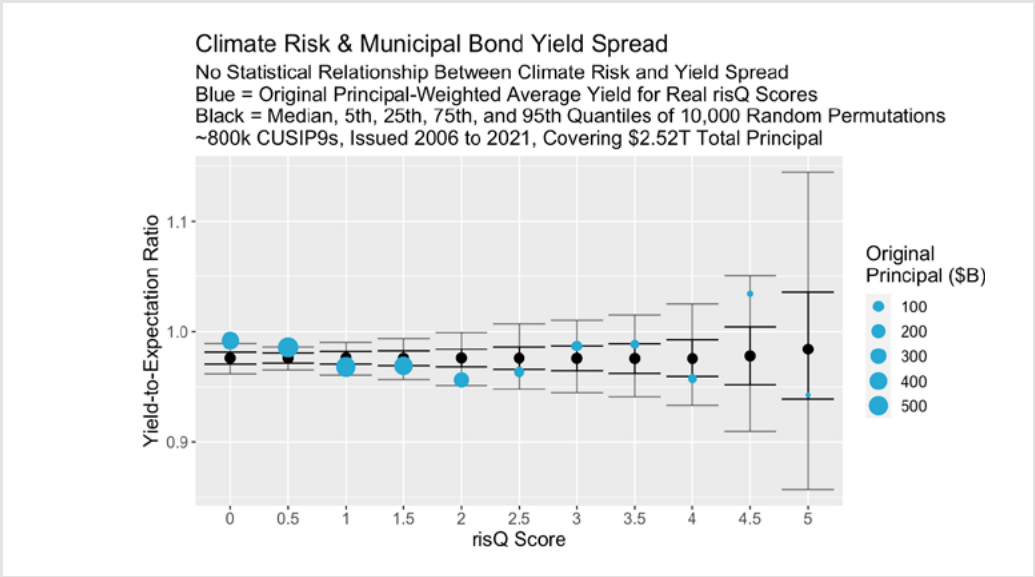


***Figure 1:*** *The Yield-to-Expectation Ratio (YER), as described in this section, is examined against the risQ Score to test the null hypothesis that physical climate risk is not priced into the municipal debt market. The black dots, black error bars, and gray error bars respectively represent the median, interquartile range, and 5th to 95th percentiles of a 10,000-member permutation test that randomly scrambles the relationship between issuers and climate risk. Blue dots are the true original principal-weighted average YER for each risQ Score bin, unscrambled. If the market is pricing in climate risk, one would expect to see the blue dots for high climate risk (e.g., risQ Scores of 3 and above) exceed the upper bounds error bars that represent random chance.*

***Source:*** *ICE Data*

We find the same lack of correlation between the YER and the individual peril scores -- the Wildfire risQ Score, Flood risQ Score, and the Hurricane risQ Score.

Next, knowing that physical climate risk came to the forefront of the collective awareness of the market after 2017's hurricane season, we repeat the exact same test but only for bonds issued between 2017 and 2021. The results in **Figure 2** lend the same insight: we still observe no significant relationship between climate risk and YER.

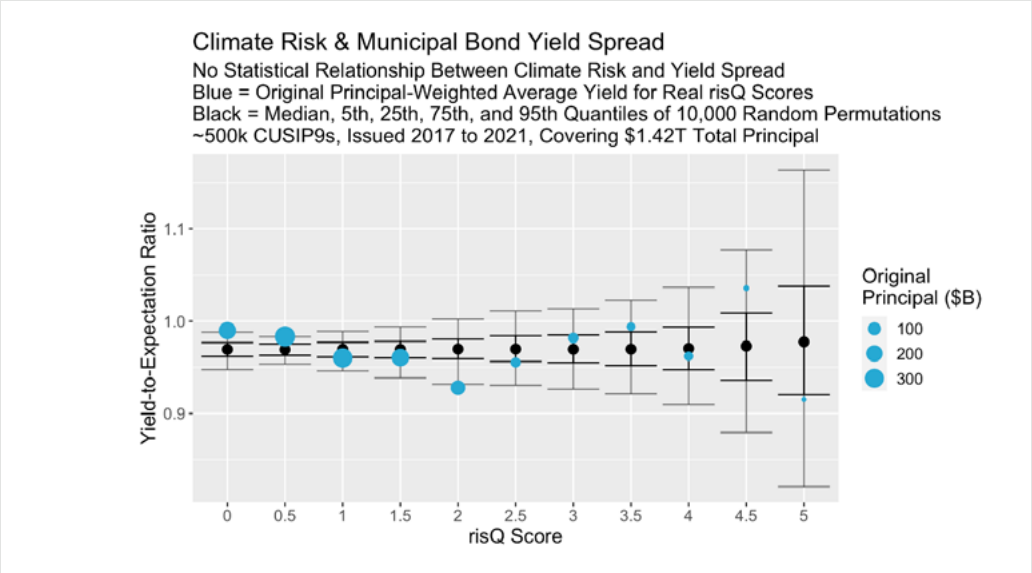


***Figure 2:*** *Same as Figure 1 but only for bonds issued from 2017 to 2021.*
***Source:*** *ICE Data*

On the other hand, a recent peer reviewed paper by Marcus Painter *did* find some evidence that, only *for bonds with longer-dated maturities*, the underwriting cost of issuance and yield increase. Published in 2020, that paper is similar in its line of questioning to ours, but the data and methodology differs to an extent. That study focuses only on sea-level rise (versus the risQ Score, which considers wildfire, hurricane, and multiple types of flood, including coastal) and only examines county obligors. As such, it relies on what is ultimately a much smaller sample size. Whereas we use a random forest to allow for potentially complex, non-linear relationships between the variables we examine (e.g., the affluence and climate risk of communities are correlated) and yield, the 2020 study uses a simpler linear model. Finally, while there are many conceptual similarities between our analysis and Painter's, it also relies on a slightly different set of independent variables and outcomes. For example, Painter uses credit ratings data directly, whereas this analysis incorporates Social Impact Scores as a proxy for what can drive credit ratings at least in part (crudely speaking, smaller communities with poorer populations have smaller tax bases and thus may often be treated as higher risk). Whereas Painter examines both yield and the total cost of issuance, we have only examined yield.

Another, even more recent paper by Goldsmith-Pinkham et al. (2021 - referred to as "GP et al."), focused again strictly on sea-level rise, shows similar insights using a structural model of credit risk. In particular, the study estimates a (very modest) ~5 basis point price premium for every standard deviation in properties exposed to 6-feet of sea-level rise. Similar to Painter, GP et al. found a more significant effect when they narrow down to a sample of long-term bonds. The authors also make the case that Painter's estimate may have been partially driven by the effects of the Great Recession, since they only find significant results after 2012.

In total, this leaves one remaining key hypothesis for us to test that is centered around *the long-term aspect* -- the idea being that, after controlling for all else, bond investors have begun to demand a premium for the risk taken in holding debt that will exist long enough to feel more dramatic consequences of climate change. As a final test, we repeat our analysis for all bonds issued from 2006-2021, but only for those with a 20+ year lifetime at the year of issuance. **Figure 3** shows the results; they do not corroborate the academic findings.

Most importantly, any potential debate around the subtler points of comparing this study with Painter's and the work of GP et al. is the reality that even if there is a subtle, small pricing of dramatic, long-term sea-level rise, climate risk is still not priced appropriately given the existential challenge it presents.

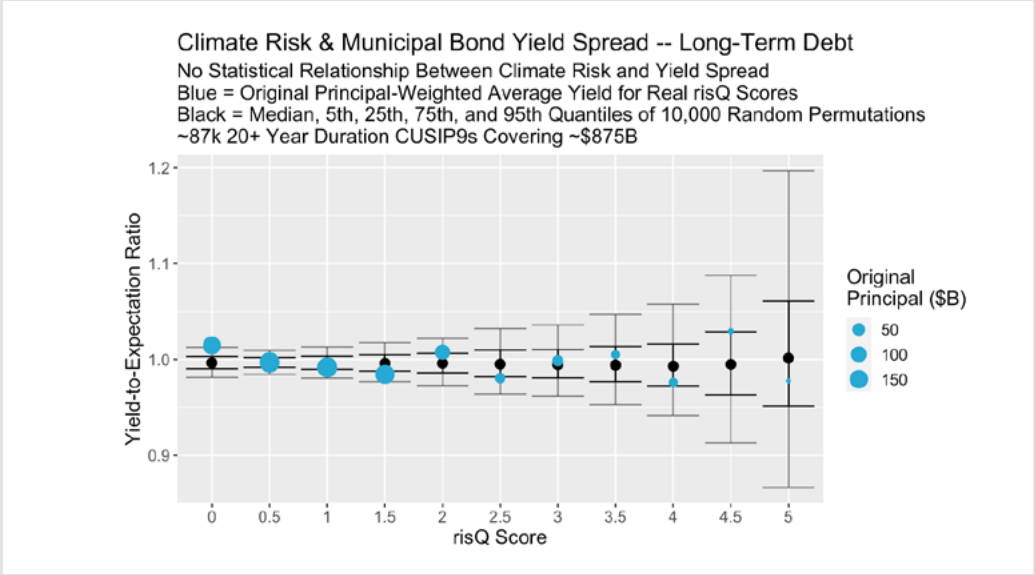


***Figure 3:*** *Same as Figure 1 but only for bonds with 20+ year maturities at year of issuance.*
***Source:*** *ICE Data*

## Why *isn't* climate risk priced into municipal bond yields (yet)?

The market is still in the early stages of reckoning with climate risk. The below reasons might partially explain why the municipal bond market has not priced in climate risk -- yet.

- **"Muni bonds rarely default."** The municipal bond market is thought of as low risk. Some of this is rooted in rules or conditions that protect lenders; e.g., many are state-backed. Much of this is just rooted in data -- compared to other asset classes, municipal bonds have historically been less risky. Because of this, systemic risk *in general* (climate and otherwise) has not been nearly as central a concern to municipal bonds as it has to insurance or mortgage-backed security markets.
- **"Climate hasn't historically caused defaults."** We are paraphrasing somewhat, an argument that we hear less and less of as the climate crisis worsens. And climate risk is now increasingly bankrupting small towns in the U.S. Since investors set the tone and ultimately drive yield expectations, if climate is expected to be a true credit risk, then yield spread should ultimately follow.
- **There is more demand for municipal bonds than supply.** Today, there is more capital for lenders to put into play than supply of municipal bond issuance. It is well known that this dynamic compresses yield spread in the market. While a large number of bond buyers are now factoring climate risk into their decisions, the Miamis of the country haven't taken a hit on credit spread yet.
- **Issuers are not clearly incentivized or equipped to disclose climate risk on their own.** Buy side participants relying on issuers' official statements will often lack critical information. While more bond buyers are operating with objective climate risk data, some are still in this situation. Much is made of the need for issuers to disclose their climate risk -- but many lack the resources to do so, especially in a standardized objective manner.
- **Ratings agencies don't bake climate risk explicitly into credit profiles of issuers … yet.** But in light of (for example) Moody's recent acquisitions of 427 and RMS, this is likely just a matter of time.

## Why does it matter and what can key stakeholders do about it?

Climate change has the potential to wreak havoc on the municipal bond market given its dependence on vastly underinsured property value -- gradually or abruptly. True reckoning with climate risk could occur through multiple trigger events, whether those events are actual climate events, policy changes or sociological ones (migration in response to and/or even in anticipation of climate disasters).

- **Bond buyers** are not being compensated for a systemic and increasing credit risk, all while operating in a low interest environment. Smaller communities and tax bases are particularly vulnerable, meaning higher yield funds likely hold outsized risk. But most importantly, *all* bond buyers are reliant on the stability of the debt market; climate change is a systemic risk that, left unaddressed, will eventually actualize and threaten market stability. Buyers arguably have more leverage than any other entity in the U.S.: in theory, they are in a unique position to demand that issuers not only disclose their climate risk but act and invest to mitigate it.
- **Bond insurers** hold the bag on 10-30 year bonds and have no means of transferring that risk through a means that is comparable to the property and casualty industry's reinsurance and catastrophe bond tools. So while events that trigger bond insurance payouts are rarer than those that trigger residential or insurance policy payouts, climate risk will at the least create an uptick in losses over time, and at the worst, a Black Swan event if many issuers were to default "in sync" (e.g., think contemporaneous, massive wildfires and/or hurricanes that devastate small, often insured and already credit impaired issuers) and/or if the often tenuous backstop of federal disaster aid were to dry up. Methodology for factoring climate risk into bond insurance underwriting decisions and premiums are still at an early stage. Since less than 10% of municipal bonds are insured, bond insurers could consider climate risk as a significant opportunity for top line growth as investors become increasingly wary. Meanwhile, insurers should consider the spatially correlated nature of climate risks -- e.g., if drought and wildfires continue to plague the American west, issuers could experience impairment, population loss risk, and property value declines en masse, regardless of whether they are the direct victims of events.
- **Regulators** hold a key to catalyzing a shift in the municipal bond ecosystem; if climate risk disclosure becomes mandatory, this would accelerate climate adaptation. Reticent issuers would have to confront climate risks, while bond buyers and insurers would eventually be operating on a more level and transparent playing field.
- **Bond issuers** will need to prepare for potential "sticker shock" in many cases -- yields don't reflect climate risk yet, but this is almost certainly a matter of when, not if. Proactivity around climate disclosures is widely perceived as a credit positive from a Governance perspective. As mentioned earlier, not all issuers are equipped and resourced to disclose climate risk: ICE Climate Risk ultimately exists to help issuers and the municipal market as a whole adapt to climate change. We do this by providing stakeholders with transparent climate risk metrics and cost-benefit analytics for resilience investment decisions. In addition, an increasing number of issuers are leveraging the municipal market to finance climate adaptation. In a landmark example from late 2021, Virginia Beach voters passed a referendum to use more than $500M in municipal bonds to finance infrastructure to combat sea-level rise. This project is among the first of its kind, backed by an analysis that estimated the economic and social benefits of investments in resilience relative to their costs. This is notable given that one of the key bottlenecks to local climate action has often been "who's going to pay for it and why?". The municipal market provides a natural channel for executing the financing of climate resilience.

## About ICE

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