

POLICY BRIEF

Pricing Climate Risks: Evidence from Wildfires and Municipal Bonds

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Executive summary

- Rising wildfire risks constitute a major but understudied economic cost of climate change. We document the growing impact of future wildfire risks on financial markets, focusing on the increasing fiscal costs associated with global warming in the context of municipal finance.
- Most school districts in the US fund their long-term capital investments by issuing bonds — a promise to pay bondholders a stream of fixed income over a specified period in exchange for upfront capital. In general, US school districts pay off this debt with local property tax revenues. This financing mechanism, therefore, creates a close link between local economic conditions and municipalities' ability to pay off debt.
- Rising economic wildfire risks, driven by valuable housing assets near vegetative fire fuels and dry weather conditions, are present not only in California but also across many parts of the US.
- We find that municipalities facing greater increases in future wildfire risks are already paying substantially more to raise capital.
- In US municipal bond markets, the increase in borrowing costs in the mid-2010s due to rising wildfire risks coincides with higher borrowing costs associated with other future climate risks, such as sea level rise or heat stress, as documented in prior studies.

- Increases in future wildfire risks have a much larger impact on school districts with higher proportions of racial minority populations and a greater reliance on local revenue sources compared to state and federal funding.
- The rise in borrowing costs due to elevating wildfire risks can strain municipal budgets, limiting their ability to provide public services and fund post-disaster recovery, which could further weaken their capacity to borrow in the future.

Outline

Recently, wildfires have imposed significant costs on the US economy. In 2018, estimated losses from wildfires reached \$30 billion (in 2024 USD), equivalent to 26% of the total damage from climate-related natural disasters in the US.¹ Even more concerning is the projected increase in wildfire risks across many parts of the United States due to climate change (Brown, Wang, and Feng, 2021).

This brief presents research findings and policy implications from an empirical study in which we examine whether financial markets are responding to projected changes in future wildfire risks. We focus specifically on the fiscal costs of climate change within the US municipal bond market, where policymakers have raised major

* This policy brief is based on the paper «Pricing Climate Risks: Evidence from Wildfires and Municipal Bonds» by Woongchan Jeon, Lint Barrage, and Kieran James Walsh, available as CESifo Working Paper No.11447 at: <https://www.cesifo.org/en/publications/2024/working-paper/pricing-climate-risks-evidence-wildfires-and-municipal-bonds>.

¹ «The U.S. billion-dollar weather and climate disasters,» National Centers for Environmental Information (NCEI) National oceanic and Atmospheric Administration (NOAA), 2024. <https://www.ncei.noaa.gov/access/billions/>. Accessed on 2024-07-31.

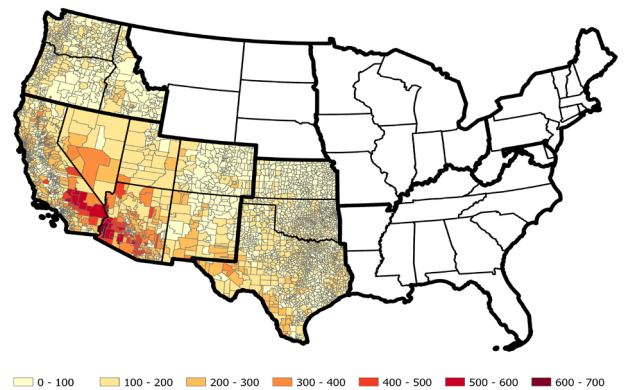
concerns,² yet little evidence has been provided. In particular, we analyze the effect of future wildfire risk changes on the US school district bond spread, defined as the additional return that financial markets require to compensate for investment risks relative to a risk-free financial product.

We find that when future wildfire risks increase by one standard deviation,³ bond spreads rise by 23 basis points, equivalent to 42% of the average spread in the data. This result indicates that municipalities facing greater increases in future wildfire risks are already paying substantially more to raise capital. The reflection of future wildfire risks in municipal borrowing costs is more pronounced in school districts with higher shares of racial minority populations and a greater reliance on local revenue sources rather than federal and state funding. We also find that housing values are already negatively affected by anticipated increases in wildfire risks, which is important because property taxes serve as the primary source of debt payment for many school districts.

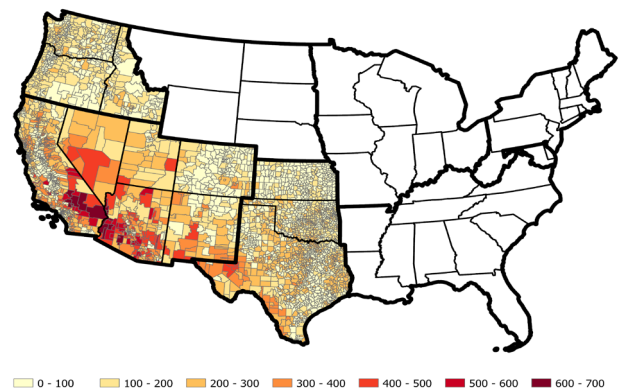
Economic wildfire risks in the United States

From an economic perspective, two key factors should be considered when assessing a borrower’s ability to pay off their debt in the face of rising wildfire risks — physical wildfire risks based on meteorological conditions and the presence of valuable assets, such as residential structures, near vegetative fire fuels. For example, a neighborhood in downtown Los Angeles, California may experience weather conditions favorable to wildfires in the future. However, the economic risk could remain limited if the area has little vegetative fuel to burn, despite its high population density. On the other hand, an area near the Grand Canyon in Arizona may also exhibit high wildfire potential in the future. Yet, from an economic perspective, the risk remains relatively low, as there are no residential structures to burn, even though it is close to fire fuels.

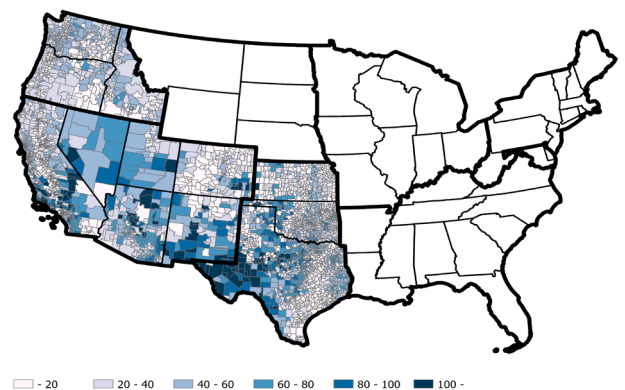
To assess the economic wildfire risk of each bond issuer, we compute the average Keetch-Byram drought index (KBDI) — a commonly used measure for physical wildfire risks — weighted by the number of housing units in areas where residential structures meet vegetative fire fuels (also known as wildland urban interface). The following figures map the historic and mid-century average KBDI, along with their differences in the Northwestern, Southwestern, and Southern Great Plains regions that have historically experienced drought index indicative of a high potential for wildfires. Overall, the Southwestern area shows a high potential for wildfires in both historical and mid-century periods. But the Southern Great Plains additionally stand out when considering the difference in average KBDI, which indicates that future economic wildfire risk changes are especially pronounced in this area.



(a) Historic weighted KBDI (1995-2004)



(b) Mid-century weighted KBDI (2045-2054)



(c) Difference

Figure 1: Wildfire Exposure by School District

² «Investing in the Future: Safeguarding Municipal Bonds from Climate Risk (Full Committee Hearing on Wednesday, January 10, 2024, 10:00 AM),» United States Senate Committee on the Budget <https://www.budget.senate.gov/hearings/investing-in-the-future-safeguarding-municipal-bonds-from-climate-risk>. Accessed on 2024-10-08.

³ Standard deviation measures how spread out a specific quantity is around its mean in the data. To present our empirical findings, we consider a hypothetical case in which wildfire risks increase by one standard deviation throughout this brief.

Risk trajectory and increasing awareness

To measure the correlation between future wildfire risk changes and municipal bond spreads, we rely on three sources of variation in the data. First, local economic wildfire risks are rising over time due to climate change. Second, many school districts issue bonds with a range of maturities to spread out their debt service over time (e.g., some set to be fully paid off in 10 years and others in 20 years), which will consequently face different levels of wildfire risks due to their distinct time horizon. Third, awareness of the perils posed by climate change have been increasing over time. These three trends, combined with a canonical panel regression approach with two-way fixed effects from a prior study examining sea level rise (Goldsmith-Pinkham, Gustafson, Lewis, and Schwert, 2023), allow us to isolate the effects of future wildfire risk changes while holding constant many other factors affecting municipal borrowing costs.

Rising wildfire risks and municipal bond spreads

One may be concerned that other economic factors, aside from climate-driven wildfire risks, could also explain rising municipal borrowing costs. To tease out the correlation between future wildfire risks and municipal bond spreads, we account for other economic indicators that could affect bond spreads, such as whether bonds are insured to cover debt payments in the event of default, how many years are left until full repayment, how often bonds are traded, or other technical aspects of debt payment such as sinkability and callability status. Importantly, we also consider local economic conditions and credit ratings that may vary over time within a district, as well as the general effects of future maturity dates on bond spreads.

The following figure presents our central estimates of the effect of future wildfire risk changes on municipal borrowing costs and how this effect has evolved over time (relative to a reference year of 2006). This result suggests that future wildfire risk changes have significantly increased municipal bond spreads since around 2014, when the Intergovernmental Panel on Climate Change (IPCC) released its widely publicized Fifth Assessment Report. On average, post-2014, when future wildfire risks increase by one standard deviation, bond spreads rise by 23 basis points, equivalent to 42% of the average spreads in the data.

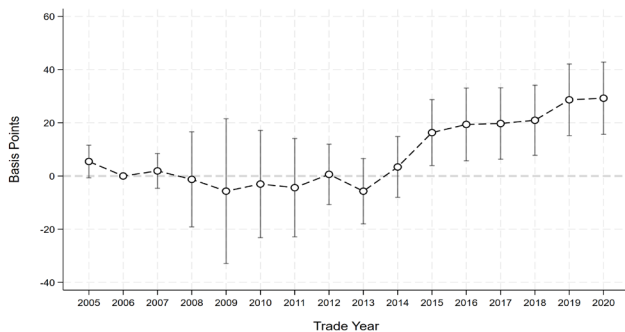


Figure 2: Effect of wildfire risk increases on municipal credit spreads

Minority shares and revenue sources

We further analyze how the impacts of future wildfire risk changes vary across school districts with differing socioeconomic characteristics. First, we categorize school districts into “high” and “low” racial minority shares based on whether the proportion of the nonwhite population is greater or less than 35%, the average nonwhite population share in the US according to the 2010 and 2020 US decennial Census. We find that as future wildfire risks increase, school districts with higher racial minority shares pay an additional 11.5 basis points in risk premiums compared to those with lower minority shares. These findings add to the growing evidence of the disproportionate fiscal costs of climate change facing lower-income and racial minority populations.

Second, we categorize school districts into “locally dependent” and “diversified” revenue sources based on whether their local-to-total revenue ratio is above or below the national average. Our analysis shows that districts more reliant on local revenue sources are having to pay an additional 11.2 basis points in bond spreads due to anticipated increases in wildfire risks compared to districts with more diversified revenue sources. In other words, investors demand higher risk premiums from municipalities with less diversified fiscal revenue sources due to anticipated changes in wildfire risks.

Increasing wildfire risks and housing values

Lastly, we examine how housing values relate to future wildfire risk changes to shed some light on a potential link between local economic conditions and municipalities’ ability to pay off debt. Specifically, if home buyers are already factoring in potential climate-related damages to their properties, housing demand may have declined in areas with higher future wildfire risks, leading to lower property values. This decline, in turn, could weaken the tax base, alerting financial markets to climate-related investment risks. We find that houses with future wildfire risks one standard deviation higher are worth \$6,000 less in 2021 (in 2017 USD) compared to statistically similar houses in 2011, equivalent to 2.3% of the average housing value in the data.

Policy recommendations

In this study, we find that US municipal bond markets demand higher returns to compensate for investment risks associated with increases in wildfire potential. This rise in bond spreads could, in turn, strain municipal budgets by raising interest payments for long-term capital investments. Importantly, reduced fiscal space will further limit municipalities’ ability to provide public services and fund post-disaster recovery, underscoring the need for interventions to reduce the fiscal costs associated with global warming.

Emerging research on the fiscal costs of climate change in an international finance context has highlighted the potential benefit of designing disaster-indexed bonds (also known as natural disaster clauses), which provide fiscal relief by postponing debt payments in the event of a severe natural disaster. Other studies have also emphasized the importance of investing in preventive measures to

adapt to future climate impacts, such as implementing fire-resilient building codes in high-risk areas. Policymakers must consider such instruments to address current and future fiscal costs of a changing climate. Future research is also needed to design financial innovations that could help share risks among local governments facing similar but independently occurring climate-related natural disasters.

References

Brown, Emily K., Jiali Wang, and Yan Feng, «US wildfire potential: A historical view and future projection using high-resolution climate data,» *Environmental Research Letters*, 2021, 16 (3), 034060.

Goldsmith-Pinkham, Paul, Matthew T. Gustafson, Ryan C. Lewis, and Michael Schwert, «Sea-level rise exposure and municipal bond yields,» *The Review of Financial Studies*, 2023, 36 (11), 4588–4635.

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