Risk of Rising Temperature and Newly Issued Corporate Debt Maturity

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Abstract:

I examine the impact of rising temperature risks on the maturity of newly issued corporate debt, emphasizing the long-term financial implications of gradual temperature trends. Firms exposed to higher temperature risks tend to prefer shorter-term debt, particularly those facing financial constraints while increasing their allocations to short-term investments. A Difference-in-Differences test on Florida firms during hurricane-prone quarters, combined with a temperature variability analysis, distinguishes short-term shocks from persistent temperature trends, confirming that long-term exposure has a more pronounced effect on the maturity of newly issued debt. A time trend analysis further captures shifts in corporate debt structures over 2002Q1–2022Q4. Firms in stricter regulatory environments issue shorter-term debt, while those in lenient regions adjust less. Although both vulnerable and non-vulnerable firms reduce debt maturity, vulnerable firms—facing higher interest expense ratios—adjust less aggressively, suggesting that product-demand elasticity influences financial policies. Larger firms shorten debt maturities for flexibility, while smaller firms, constrained by market access, do not. Credit ratings also shape responses, with higher-rated firms maintaining longer maturities. Findings are robust to the nearest-neighbor matching, propensity score matching, and placebo tests addressing endogeneity concerns.

Keywords: Climate risks, debt maturity, short-term investment, strict regulations, interest expense, credit ratings.

JEL classification: G30, G32, Q54.

1. Introduction

Rising global temperatures pose mounting challenges for businesses, affecting operational stability, regulatory compliance, and financial risk management. Gradual temperature trends, in particular, hinder firms' ability to plan long-term, influencing their capital structure decisions. While prior research has extensively examined climate risk in the context of equity markets, asset pricing, and firm valuation (e.g., Ramiah et al. (2013); Krueger et al. (2020); Huynh et al. (2020); Ilhan (2020); Barnett (2023)), less attention has been paid to its implications for corporate financial policy. Prior studies have explored the relationship between climate risks and existing corporate debt maturity (Goodell et al., 2025), but the effect of temperature risk on the maturity of newly issued debt remains largely unexamined. I address this gap by investigating how firms adjust their newly issued debt maturity strategies in response to rising temperature trends.

I show that rising state-level average temperatures, reflecting long-term exposure and gradual trends, lead to shorter debt maturities.[1] High temperatures, a key driver of climate change, increase physical and transition risks, disrupting operations, supply chains, and productivity. Industries like agriculture, construction,

[1] I specifically examine the maturity of newly issued debt, rather than the maturity structure of existing debt. I analyze how elevated temperature risks influence firms' decisions when determining the maturity of upcoming new debt issuances.

and energy are especially affected (e.g. Balvers and Huang (2007); Balvers et al. (2017); Heo (2021); Hugon and Law (2018); Pankratz et al. (2023)).[2] Since corporate debt maturity decisions are primarily influenced by long-term planning, average temperature serves as a stable indicator of firms' financial adjustments to temperature risks. To mitigate the impact of short-term fluctuations, I use a 4-quarter moving average to smooth seasonal variations and noise. [3]

However, recognizing that temperature shocks may affect firms' new debt issuance maturity, this study explicitly differentiates between persistent risk and short-term temperature disruptions—structural versus transitory effects. First, I utilize a 4-quarter rolling standard deviation of average temperature, capturing the impact of unpredictable fluctuations, and distinguishing gradual temperature trends from sudden temperature instability. I also use a difference-in-differences (DiD) test on Florida firms, where hurricane-prone quarters serve as a treatment group, isolating the effects of extreme weather shocks on corporate new debt issuance maturity. This approach aligns with Brown et al. (2021), who find that climate shocks, such as severe winter weather, prompt firms to rely more on short-term credit. The results show that both long-term temperature trends and short-term fluctuations influence debt maturity decisions, with long-term temperature changes having a more significant effect. A Wald test confirms that persistent warming trends, rather than temporary shocks, are the primary drivers of debt maturity adjustments, aligning with Ilhan et al. (2021) on the role of regulatory uncertainty and climate risk perceptions in shaping corporate behavior.[4]

To examine changes in the term structure over the sample period, I incorporate a time trend analysis to assess whether the shift toward shorter-term debt issuance reflects a broader market trend or is driven by firms exposed to higher temperature risk, following Gounopoulos and Zhang (2024). The results indicate that

[2] The operational strain, including reduced worker productivity and higher cooling costs, leads firms to issue shorter-term debt as a response to these risks. High temperatures elevate costs and financial instability, prompting firms to reconsider long-term commitments. Focusing on high temperatures aligns with evidence that firms shorten debt maturities to preserve financial flexibility. In contrast, low temperatures are less frequently linked to the systemic, long-term risks associated with climate change. Therefore, emphasizing high-temperature risk is consistent with broader climate and financial risk management studies.

[3] Climate risks are often discussed in terms of long-term trends (e.g., rising temperatures (Balvers, Du and Zhao (2017)), and sea level rise (Ilhan (2020)) rather than short-term shocks. Long-term risks can affect a firm's strategic vision and financial planning, influencing debt maturity decisions as firms look to hedge against future disruptions. On the other hand, short-term shocks only have an immediate, temporary effect on financial decisions. Hence, long-term exposure is a more appropriate focus when analyzing corporate financial behavior.

[4] The consistent impact of average temperature across all models highlights that persistent warming trends primarily drive these adjustments, with short-term shocks acting as amplifying factors.

the influence of temperature risk on new debt maturity has intensified over time, suggesting that the shift is primarily driven by rising temperature-related financial risks rather than general temporal trends.

To assess industry-specific responses to temperature risk, I distinguish between vulnerable and non-vulnerable sectors. Vulnerable industries—such as agriculture, mining, transportation, and real estate, per Giglio et al. (2021)—face direct climate exposure and more elastic product demand, making them susceptible to temperature-induced revenue volatility. In contrast, non-vulnerable industries like technology, healthcare, and grocery face lower climate sensitivity and more stable demand. I find that firms in vulnerable industries significantly shorten new debt maturities in response to rising temperatures, suggesting that demand elasticity shapes financial policy adjustments. This aligns with corporate finance theories linking business risk to capital structure (e.g., Modigliani and Miller (1958); Myers (1977)). Propensity score matching further reveals that vulnerable firms face higher borrowing costs and issue shorter-term debt than their non-vulnerable peers.[5] [6]

Moreover, financially constrained firms exhibit a stronger preference for shorter-term debt, consistent with Kale and Noe (1990), who show that even without transaction costs, an inverse relationship exists between firm quality and debt maturity. Furthermore, firms with high credit ratings maintain longer-term debt maturity despite temperature risks, whereas lower-rated firms shorten debt maturities at a higher rate, reflecting heightened risk perceptions by creditors.[7]

Additionally, firms headquartered in states with stricter environmental regulations tend to issue shorter-term debt, seeking greater financial flexibility to manage regulatory uncertainty, compliance costs, and cash flow volatility.[8] This behavior aligns with the pecking order theory (e.g., Myers (1984); Shyam-Sunder

[5] Propensity Score Matching (PSM) plays a critical role in mitigating selection bias stemming from observed characteristics, effectively addressing endogeneity issues that may arise from unobserved factors, simultaneity, or measurement error. By establishing a framework to balance the covariates between treated and control groups, the PSM analysis enhances the validity of causal inferences drawn from observational data.

[6] This aligns with the trade-off theory of capital structure (Modigliani & Miller, 1958), which suggests firms balance the benefits of debt (tax shields) against financial distress costs.

[7] Firms with high leverage or low creditworthiness face higher borrowing costs and rollover risks. Shorter maturities are not a choice but a constraint imposed by creditors. Lower-rated firms lack flexibility and face difficulty rolling over long-term debt.

[8] Following Huynh, Nguyen, and Truong (2020) and Javadi and Masum (2021), this study determines firms' exposure to temperature risk based on the state location of their headquarters. Prior research suggests that firms' headquarters locations are usually close to their core business activities and major operational centers (Coval and Moskowitz (1999); Pirinsky and Wang (2006); Korniotis and Kumar (2013); Tuzel and Zhang (2017)). Additionally, financial and strategic decisions—including capital structure choices—are largely made at the headquarters level, making it a relevant proxy for temperature risk exposure. While some firms operate across multiple states, headquarters-based exposure remains relevant, as regulatory policies, tax structures, and key governance decisions are primarily determined at the state level.

and C. Myers (1999)), which posits that firms choose financing sources based on capital costs and information asymmetry. Elevated temperature risks and associated cash flow uncertainty increase the cost of long-term debt, prompting firms to favor shorter maturities to mitigate perceived risk for external investors.[9]

Firm size also shapes responses to climate risk. Larger firms tend to shorten debt maturities to preserve financial flexibility, consistent with theories suggesting that high-quality firms use short-term debt to signal creditworthiness (e.g., Flannery (1986); Diamond (1991)). While smaller firms exhibit weaker adjustments due to limited financing options, the analysis reveals that it is credit quality, not size alone, that drives maturity decisions: firms with high credit ratings are less likely to shorten maturities. Additionally, the geographic dispersion of larger firms contributes to their debt strategies, as exposure to temperature risk varies across states.

To further address potential endogeneity concerns, I incorporate nearest-neighbor-matched sample analyses to rigorously assess the impact of high-temperature trend risks on debt maturity while controlling for key firm characteristics. The results reveal that firms in the top quartile for high-temperature trend risks issue significantly shorter maturity debt than their low-risk counterparts. This finding strengthens the evidence of a negative relationship between high-temperature trend risks and debt maturity, effectively ruling out time-trend-based explanations.[10]

New corporate debt issuance allows firms to raise capital for purposes such as expansion, capital investment, acquisitions, or working capital. Rising temperatures introduce unique operational and financial risks—such as reduced profitability, credit downgrades, and increased borrowing costs (e.g., Pankratz et al.

[9] Barnea and Rubin (2010) highlight that insiders often push for CSR investments beyond the value-maximizing level for the firm. Benlemlih (2017) find that higher CSR activities reduce debt maturity. This aligns with our finding that firms in stricter regions—subject to greater stakeholder scrutiny and allocating more capital to ESG and CSR initiatives—issue shorter-term debt. Benlemlih (2017) suggests that shorter-term debt helps curb CSR overinvestment by subjecting managers to frequent creditor oversight. The debt overhang problem (Hart & Moore, 1995) indicates that firms with high uncertainty about future cash flows prefer shorter maturities to mitigate underinvestment risks.

[10] The findings align with well-established theories. Myers (1977) proposes using short-term debt to finance assets-in-place, maturing before growth options are exercised. Jensen and Meckling (1976) argue that equity holders pursue risky projects at debtholders' expense from an asset substitution perspective. Smith and Warner (1979) and Barnea et al. (1980) suggest mitigating this with shorter debt maturities, as creditors are more likely to monitor borrowers frequently, incentivizing equity holders to manage risks and investments efficiently. Maksimovic and Titman (1991) show that firms committed to better employee benefits tend to have lower debt ratios and limit their debt usage.

(2023); Nguyen and Phan (2020); Painter (2020)). Due to these risks, creditors prefer shorter-term debt to mitigate long-term losses and default risks, allowing more frequent monitoring of firms' financial conditions (Brown et al., 2021). The theory of risk capital suggests that perceived risks, such as temperature changes, impact the cost of capital (Erel et al., 2015). While longer-term debt typically reduces refinancing risk, firms exposed to significant temperature-related threats may prefer shorter maturities to preserve flexibility and adapt to evolving climate conditions.

Almeida et al. (2011) and Goyal and Wang (2013) highlight that firms favor short-term debt during uncertain times to avoid the constraints of long-term financing. While short-term debt necessitates frequent refinancing and exposes firms to rollover risk, it remains attractive due to its lower initial cost than long-term debt (e.g., Bharath et al. (2007); Graham et al. (2008)). Moreover, it allows firms to frequently reassess conditions and potentially refinance at better terms if political risks and interest rates improve (Diamond (1991)). Locking into long-term debt under high uncertainty risks overpayment, making short-term debt a flexible option that offers refinancing opportunities as conditions stabilize.

I investigate how temperature-related risks influence corporate debt maturity decisions, revealing firm-level adjustments to rising climate uncertainty. By highlighting heterogeneity across firms, the analysis offers practical insights for financial decision-makers. Consistent with real options theory, the findings suggest that elevated temperature risks, through operational and regulatory exposures, drive firms to favor shorter-term debt, preserving flexibility to reassess and adapt financing strategies in response to evolving climate developments.

2. Literature Review and Hypotheses Development

The climate finance literature explores key aspects such as risk pricing, hedging strategies, investor attitudes, and climate risks' impact on corporate decision-making. A significant body of research focuses on how climate change affects asset prices (e.g., Bernstein et al. (2019); Venturini (2022)), stock returns, financing costs, and corporate policies like cash holdings and leverage (e.g., Ding et al. (2021); Balvers et al. (2017); Javadi et al. (2023)). Barnett (2023) finds that increased climate change severity prompts investors

to adopt more risk-averse positions, demanding higher risk premiums. Similarly, Balvers et al. (2017) identify a negative risk premium associated with temperature shocks, raising equity capital costs. Aslan et al. (2022) observe reduced bank credit extension in high-pollution regions post-Paris Agreement. Institutional investors recognize climate risks as financially material (Krueger et al., 2020) and engage with firms to improve climate risk disclosures (Ilhan et al., 2023), influencing firms' debt structuring to mitigate financial risks.

Regulatory uncertainty also affects firms' climate-related financial decisions. Ilhan et al. (2021) show that climate policy uncertainty raises costs for carbon-intensive firms. This study finds that firms shorten new debt issuance maturities in response to persistent climate risks and regulatory uncertainty, with adjustments intensifying over time. Moreover, Ilhan (2020) highlights how sea level rise risks influence investment decisions, distinguishing between persistent risks and short-term shocks, with long-term temperature trends being the primary driver of firms' borrowing behavior.

Further literature examines the influence of climate risks on corporate policies, such as capital structure (Nguyen and Phan (2020)), cash holdings (Heo (2021); Javadi et al. (2023); Gounopoulos and Zhang (2024)), and firm earnings (Hugon & Law, 2018). Financially constrained firms often adopt conservative strategies in response to climate uncertainties. Studies link climate policies to corporate behavior: Balachandran and Nguyen (2018) show that rising carbon management costs dampen managerial confidence, leading to conservative financial policies. Ginglinger and Moreau (2023) note challenges faced by firms exposed to climate risks, including higher financing costs. Javadi and Masum (2021) find that perceived climate risks exacerbate bank loan costs, particularly for firms with lower credit ratings seeking long-term financing. Painter (2020) reveals that municipalities vulnerable to climate risks face lower credit ratings and higher bond yields. Other research shows that firms' environmental performance affects bond premiums (Huynh and Xia, 2021) and that climate risks influence debt-related tax shields (Saba, 2024). Giglio et al. (2021) find that firms in vulnerable industries face higher borrowing costs and increased investor scrutiny.

The volatility introduced by high-temperature risks amplifies uncertainties in the business environment, potentially destabilizing financial structures. On the supply side, creditors may prefer short-term

debt due to the heightened risks of climate-related events, granting them greater flexibility. While firms typically favor long-term debt to mitigate rollover and liquidity risks, increasing uncertainties drive borrowers to adopt shorter-term debt, enhancing financial flexibility and reducing costs, while aligning their investments with maturity. This leads to the following hypothesis:

H1: *Firms with higher temperatures issue shorter-term debts and maintain more short-term investments.*

The impact of high-temperature risk on corporate performance and policies, particularly regarding debt maturity choices, is significantly influenced by firm characteristics. Firms facing higher financial constraints are more vulnerable to high-temperature risks, which hinder their ability to fulfill long-term financial commitments and secure additional long-term debt. Heo (2021) and Javadi et al. (2023) demonstrate that firms exposed to adverse climate conditions tend to increase their cash holdings.

H2*: Firms with higher financial constraints issue shorter-term debt.*

The impact of high-temperature risks on debt maturity varies between large and small firms. Smaller firms, with limited resources, often lack the flexibility to adjust their debt maturities in response to climate risks. In contrast, larger firms, benefiting from better access to capital and greater resources, are more able to manage these risks (Kolk & Pinkse, 2005). Due to their size, increasing regulatory pressures, and broader geographic exposure to high-temperature risks, larger firms are more likely to issue shorter-term debt as a precautionary measure and signal of financial prudence. Smaller firms, with more localized operations and simpler structures, are less affected by these risks.

H3*: Large and small firms tend to shorten the maturity of newly issued debt in response to high-temperature risks.*

Higher temperature risks affect corporate operations and cash flows through both physical and transition risks. Physical risks directly impact production processes, while transition risks stem from the shift toward a low-carbon economy and evolving regulations. This creates uncertainty in long-term financial commitments, especially for firms in vulnerable sectors. These firms face increased scrutiny over their

Corporate Social Responsibility (CSR) and Environmental, Social, and Governance (ESG) commitments, leading to higher investments in CSR initiatives. Consequently, they tend to issue shorter-term debt to manage risks from heightened expectations and operational uncertainties. However, due to higher interest expenses, they often issue debt with slightly longer maturities than non-vulnerable firms. Hempel (2024) suggests this approach helps secure favorable returns and minimize rollover risk, stabilizing financing costs. Bolton and Kacperczyk (2021) find that firms with high carbon exposure face higher borrowing costs, further incentivizing them to favor shorter-term debt to mitigate financing risks in an evolving regulatory landscape.

Similarly, firms in states with stricter environmental regulations issue shorter-term debt more than those in less regulated regions, as such regulations introduce uncertainty around compliance costs, potential fines, and future policy shifts. These firms opt for shorter-term debt issuance to retain financial flexibility and mitigate risks related to evolving regulatory landscapes, informing the basis for the next hypotheses.

H4*: Firms operating in regions with stricter regulations tend to issue shorter-term debt than lenient regions.*

H5*: Firms operating in vulnerable industries issue shorter-term debt than non-vulnerable counterparts.*

3. Data and Methodology

3.1. Sample

The dataset for this study is compiled from multiple sources to provide a comprehensive view of firm characteristics and debt issuance activity. Firm-level data is sourced from the Center for Research in Security Prices (CRSP) and Compustat. The credit ratings data is sourced from the Compustat and Capital IQ merged database. At the same time, detailed information on debt issuances in the United States from 2002 to 2022 is obtained from the SDC Platinum database by Refinitiv Eikon. This database covers many debt types, including public bond issues, private debt (non-Rule 144A), syndicated loans, and Rule 144A issues. The full sample consists of 79,289 individual debt issuance observations at the issue level, encompassing public bonds, private debt (non-Rule 144A), Rule 144A securities, and syndicated loans. In the first step, these observations are aggregated to the firm-

quarter-issue-type level, resulting in 41,380 consolidated observations. The data is then further aggregated to the firm-quarter level by calculating the issue-size-weighted average maturity of all new debt issued by a firm within that quarter: $\frac{\sum_j(new\ debt\ issued_{ijt} \times maturity_{ijt})}{\sum_j(new\ debt\ issued_{ijt})}$, where j indexes different issue types. This final aggregation yields 8,872 firm-quarter observations. The use of the issue-size weighted average maturity accounts for differences in issuance volume and reflects the overall financing strategy in response to temperature risk.[11] he primary variable, Log(Maturity), is the natural logarithm of newly issued debt maturity at the firm-quarter level, ensuring normalization and comparability across varying maturities, as per Brockman et al. (2010) and Huang et al. (2023). The results remain consistent with untransformed maturity.

Temperature data, sourced from the National Centers for Environmental Information (NCEI), includes monthly state-level average temperatures from 2002 to 2022, aggregated into quarterly averages and matched to firm headquarters' locations.[12] This approach aligns with frameworks by Balvers and Huang (2007) and Balvers et al. (2017), linking temperature shocks to productivity. A 4-quarter moving average smooths short-term fluctuations, such as seasonal changes or sudden spikes, to focus on long-term temperature trends. Additionally, a 4-quarter rolling standard deviation is calculated to capture temperature shocks. The main regression model analyzes persistent temperature risk—examining the long-term effects of rising temperatures on corporate debt maturity decisions.

To improve interpretability and account for differences in variable scales, the average temperature is rescaled by dividing by 10. As a result, the estimated coefficient reflects the effect of a 10°F increase in temperature on the logarithm of debt maturity. This transformation does not affect

[11] The firm-level focus justifies consolidation as this approach smooths out idiosyncratic variations across different debt instruments and better captures firms' strategic responses to rising temperature risk. The dependent variable (the maturity of debt issuance) is already a size-weighted average of all new debt issuances, issue-level fixed effects would not apply. The consolidated sample assumes that a firm's overall maturity decision matters, rather than the specific type of each issuance. Industry and firm fixed effects can help control for differences in debt issuance patterns across firms. Year-quarter fixed effects account for macroeconomic conditions that influence overall debt markets.

[12] https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/statewide/time-series

statistical significance or the overall relationship but ensures a more readable coefficient magnitude. Lastly, the climate uncertainty policy index and debt ceiling relative frequency data are sourced from policyuncertainty.com. To reduce the impact of extreme outliers, all variables have been winsorized at the 1st and 99th percentiles.[13]

3.2. Methodology

For the new debt issuance sample, the following panel regression with firm-fixed effects and year-quarter fixed effects is used:

$$Log(Maturity)_{it} = a + Avg_temperature_{it-1} + ROA_{it-1} + Size_{it-1} + Cash\ reserve_{it-1} + Q\ ratio_{it-1} + D/E\ ratio_{it-1} + LA\ ratio_{it-1} + currentratio_{it-1} + \lambda_i + \zeta_t + \varepsilon \quad (1)$$

In Equation 1, the variable $Avg_temperature_{i\text{-}t}$ is the average quarterly temperature for the quarter $t\text{-}1$ for firm i, scaled by 10 to maintain similarities in scales. Log($Maturity$) is the natural logarithm of the newly issued debt maturity for i^{th} company in t^{th} year-quarter, λ is the firm-fixed effect, ζ is the year-quarter fixed effect.[14] As control variables, ROA is the return on assets, $D/E\ ratio$ is debt to equity ratio, a proxy for leverage, $LA\ ratio$ is the liability-asset ratio, a proxy for financial constraints, $Size$ is firm size computed as the logarithm of total assets, $Cash_reserve$ is the ratio of cash and short-term investment to total assets, $Q\ Ratio$ is Tobin's Q ratio for the firm, proxying for bankruptcy costs and collateral value. The independent and control variables are lagged by one year-quarter to account for time dynamics, mitigate endogeneity issues, improve model specification, and enhance predictive performance. This approach allows for capturing the delayed impact of independent variables on $Log(Maturity)$, aligning with the time frame in which new debts are issued and their effects materialize.

To evaluate firms' perspectives on short-term debt amid climate risks, this paper utilizes the short-term investment to total investment ratio (STI) as a proxy for liquidity. While STI offers insights into liquidity and

[13] Although unreported, I run additional regressions without winsorization to test whether extreme values drive the results. The results remain consistent.

[14] Utilizing year-quarter fixed effects (FE) captures time-specific shocks or macroeconomic conditions that vary quarterly, such as seasonal economic factors, policy changes, or fluctuations in financial market conditions that impact firm behavior within a specific quarter of a given year. This approach is especially valuable when the dependent variables (e.g., new debt maturity) or other independent variables exhibit quarterly changes, necessitating control for these fluctuations that influence all firms during the same period.

financial strategies, it represents only one facet among several indicators used to gauge firms' diminished dependence on short-term debt in response to climate concerns. The quarterly data on short-term investments are extracted from the CRSP-Compustat merged database (Item name: "Short-Term Investments- Total (IVSTQ)").[15] Similarly, data on total long-term investments is sourced from the same database (Item name: "Long-Term Investments- Total (IVLTQ)"). By aggregating IVSTQ and IVLTQ, the total investment for each firm in every quarter is derived. In regression models, the standard errors are robust and clustered at the firm and year-quarter levels. The following equation is used:

$$STI_{it} = a + Avg_temperature_{it-1} + ROA_{it} + Size_{it} + Cash\ reserve_{it} + Q\ ratio_{it} + D/E\ ratio_{it} + LA\ ratio_{it} + currentratio_{it} + \lambda_i + \zeta_t + \varepsilon \quad (2)$$

4. Empirical Results

4.1 Baseline Test Results

Panel A of Table 1 presents the summary statistics for the sample variables. The mean natural logarithm of newly issued debt maturity is 0.957, with a maximum of 1.699. The average temperature is 55.59 degrees Fahrenheit, with a maximum of 94.83, and a minimum of 8.56 (not scaled). The untransformed new debt issuance maturity has a mean of 11.63 years, with a maximum of 35.33 years and a minimum of 3.02 years. Panel B presents the Pearson correlation matrix, showing that none of the variables in the same regression model have high correlations, thus addressing multicollinearity concerns. Additionally, Pearson's correlation test reveals a negative relationship between Log(Maturity) and average temperature, as well as a negative relationship with untransformed maturity.

[Table 1 here]

I explore the effect of increasing temperature risks on debt maturity by analyzing the average quarterly temperature presented in Table 2. The analysis employs both fixed effects panel regression models, with and without instruments, for robustness. Column 1 uses a fixed effects model with year-quarter and firm fixed effects to model Log(Maturity). Column 2 presents the regression results from the panel data models, as

[15] IVSTQ represents currently marketable investments as presented in the current asset section, and IVLTQ represents the summation of investments and Advances - Equity Method (IVAEQQ) and Investments and Advances - Other (IVAOQ) variables in the CRSP database.

outlined in Equation 1, using a two-stage least squares (2SLS) approach. In this model, the average temperature from two quarters earlier ($Avg_temperature_{t-2}$) serves as an instrument.[16] The average temperature coefficient is negative and statistically significant at a 1% significance level both in the 2SLS model and the fixed effects model with control variables included. Specifically, a ten-degree Fahrenheit increase in the average temperature is associated with a 1.74% decrease in the 2SLS model (equivalent to a 1.74% decrease in original years to maturity) and a 2.14% decrease in the logarithm of newly issued debt maturity (equivalent to a 2.14% decrease in original years to maturity) with fixed effect panel model.[17] If the original maturity is 10 years and the temperature increases by 10 degrees Fahrenheit, for example, original maturity would drop to around 2.52 months as per the fixed effects model, and by 2.06 months as per the 2SLS model. The results indicate that firms tend to reduce the maturity of newly issued debt in response to high-temperature risks.[18]

[Table 2 here]

The regression results in Columns 3 and 4 of Table 2 indicate significant findings regarding short-term investments (STI). A ten-degree Fahrenheit rise in average temperature correlates with a 0.025-unit increase in STI in the fixed effect model, and a 0.055-unit increase in the 2SLS model (keeping both the average temperature of the concurrent quarter and the $Avg_temperature_{t-2}$ as instruments), statistically significant at

[16] 2SLS models are a common approach to address endogeneity in regression models using instrumental variables (IV). In this context, by using 2-quarter lagged temperature ($Avg_temperature_{t-2}$) as instruments, the model tackles potential endogeneity in the relationship between $Avg_temperature_{t-1}$ and debt maturity. This IV isolates the variation in the explanatory variable that is unrelated to the potential endogeneity. The IV is strongly correlated with the endogenous explanatory variable (in this case, $Avg_temperature_{t-1}$'s direct or indirect effect on debt maturity). The 2nd lag temperature ($Avg_temperature_{t-2}$) reflects the effects of earlier temperature trends on firms' longer-term adjustments. As firms plan debt maturities based on prior environmental impacts or trends, this 2nd lag variable is relevant. The first-stage F-statistics of the IV in the 2SLS model is above 10, proving the strength of the IV. The p-values of the Hansen test and Sargan test are higher than 0.1, proving that the instrument is valid and exogenous.

[17] The dependent variable here is the natural logarithm of newly issued debt maturity, so the interpretation involves a percentage change in debt maturity for a unit change in the independent variable (temperature in °F, scaled by 10). The relationship is multiplicative because of the log transformation, meaning the interpretation here refers to relative percentage changes in debt maturity. The coefficients (-0.017 in 2SLS and -0.021 in the FE model) represent the percentage change in the logarithm of maturity (Log(Maturity)) for a 10°F increase in average temperature. To interpret the results in terms of the original number of years, back-transforming the results from the logarithmic scale using exponentiation is employed. To find the approximate decrease in the original years to maturity, the following formula is used: Percentage change in original maturity =$[100\times(\exp(\text{Coefficient})-1]$, where exp(Coefficient) denotes the exponential function of the coefficient. So, for the 2SLS model: $\exp(-0.017)\approx 0.983$. So, the percentage change in original maturity will be $100\times(0.983-1) \approx 1.74$ %. Similarly, for the FE Model (Coefficient = -0.021), after exponentiating the coefficient $[\exp(-0.021)\approx 0.979]$, I get the percentage change in original maturity by: $100\times(0.979-1)=100\times(-0.021)=-2.1\%$. So, for a 10°F increase in temperature, the Log(Maturity) decreases by approximately 2.1%, in the fixed-effects model.

If the original maturity is 10 years and the temperature increases by 10 degrees Fahrenheit, for example, the original maturity would drop to around-$[10\times 1.74/100]\approx 0.17$ years or 2.06 months. A 20°F increase would lead to a decrease of 4.1 months in original maturity for a 10-year loan. Similarly, for the fixed effects model, for a 10°F increase in temperature, the Log(Maturity) decreases by approximately $[10\times 2.1/100]\approx 0.21$ years or 2.52 months.

[18] Unreported in the paper, the residuals from the regression of Log(Maturity) on average temperature, controlling for other factors, follow an approximately normal distribution with no observable patterns or systematic deviations. This indicates that the model assumptions hold, reinforcing the robustness and credibility of the findings.

10% and 1% levels respectively. Firms often allocate capital to short-term investments to enhance liquidity and address immediate climate-related challenges. They finance these initiatives with short-term debt instruments such as commercial paper or short-term loans, ensuring debt maturity aligns with investment timelines for timely repayment. High-temperature risks can create uncertainty in long-term cash flow projections, prompting caution in committing to long-term debt. By funding short-term investments with short-term debt, firms demonstrate a commitment to sustainability and risk management, meeting stakeholder expectations. This supports hypothesis H1, suggesting that firms, anticipating increased business uncertainties and potential financial disruptions from higher temperatures, mitigate risks by preferring short-term debt in their capital structure and maintaining more short-term investments.

Although the average reduction in new debt issuance maturity for a 10°F increase may appear small in absolute terms, when compounded over time, even minor shifts in firms' financing strategies can have meaningful implications for capital allocation and risk management.

4.2. Temperature Variability, Policy Uncertainty, and Changes in the Term Structure

4.2.1. Separating persistent temperature risk and temperature shocks

To distinguish persistent temperature risk from short-term temperature shocks, I introduce a temperature variability measure that captures fluctuations in temperature over time, beyond its average level. Specifically, for each firm's headquarters state, the standard deviation of temperature is computed over a rolling 4-quarter window. This approach differentiates between firms' long-term adaptation strategies in response to sustained high-temperature exposure and short-term financial adjustments triggered by sudden and extreme fluctuations. The rolling window further smooths out short-term randomness, ensuring a more stable measure of temperature volatility. To calculate this, for each quarter *t*, I calculate the mean of the average temperature values for that quarter and the three previous quarters (i.e., quarters *t, t−1, t−2*, and *t−3*), and then I calculate the standard deviation using the formula:

$$Temperature_volatility = \sqrt{\frac{1}{n-1}\sum_{j=0}^{3}(Avg_temperature_{t-j} - \overline{Avg_temperature_t})^2}$$

where $Avg_temperature_{t-j}$ represents the average temperature in quarter t-j, and $\overline{Avg_temperature_t}$ is the mean of four quarters, and n is 4. I substitute $Avg_temperature_{it-1}$ in Equation (1) with $Temperature_volatility_{it-1}$, and introduce additional control variables.[19] These include the asset-to-liability (AL) ratio, which represents financial flexibility, the income-to-sales ratio, and the return on equity (ROE) ratio, to signify profitability. Table 3 Column 1 shows that $Temperature_volatility$ is negatively and statistically significant (coefficient= -0.0052, t-value= -2.22) at a 5% level. This suggests that firms facing higher temperature variability (uncertainty in temperature trends) issue shorter-term debt. However, the magnitude of this effect is notably smaller than that of *Avg_temperature* in Column 1 of Table 2, emphasizing that while firms react to climate shocks, persistent long-term warming trends play a more dominant role in shaping debt maturity decisions. Temperature volatility primarily drives reactive, short-term financial adjustments, such as changes in working capital or investment allocation, rather than influencing long-term debt structure. To formally test whether the impact of *Avg_temperature* is significantly stronger than *Temperature_volatility*, a Wald test is conducted using regression results from Column 1 of Table 2 and Column 1 of Table 3. The null hypothesis states that the coefficients of *Avg_temperature* and *Temperature_volatility* are equal. The Wald test statistic is computed using the formula:

$$\frac{(Coefficient\ of\ Avg_temperature - Coefficient\ of\ Temperature_volatility)^2}{(Standard\ error\ of\ Avg_temperature)^2 + (Standard\ error\ of\ Temperature_volatility)^2}$$

Substituting the values from the regression results, I get: $\frac{(-0.0212-(-0.0052))^2}{(0.0077)^2+(0.0023)^2} = 3.97$. For a 2-tailed chi-square test with 1 degree of freedom at a 5% significance level, the critical value is approximately 3.841. Since the Wald statistic (3.97) exceeds the critical threshold, the null hypothesis is rejected, confirming that long-term temperature trends exert a stronger influence on firms' debt maturity choices than short-term temperature shocks.

4.2.2. Economic Uncertainty

To examine how new debt issuance maturity responds to high-temperature risk amid economic uncertainty from climate policies, I utilize the U.S. Climate Policy Uncertainty (CPU) Index, developed by

[19] An instrumental variable approach (2SLS models) risks overfitting in the first stage, introducing noise into the second-stage estimation. By using panel FE from the latter regression models, I avoid the potential distortions that can arise from an imperfect instrument. Previous research on climate risk and corporate finance decisions (Balvers et al. (2017); Nguyen and Phan (2020); Javadi et al. (2023)) predominantly employs panel FE models rather than IV approaches, given the exogeneity of climate variables.

Gavriilidis (2021). The CPU index is constructed by identifying climate uncertainty-related terms in eight major U.S. newspapers, scaling the number of relevant articles per month by the total number of articles in the same period. These series are then standardized, averaged across newspapers by month, and normalized to have a mean value of 100 from April 1987 to August 2022. To assess the interaction between climate policy uncertainty and high-temperature risks, the CPU index (scaled by 100) is interacted with Avg_Temperature in the following model:[20]

$$Log(Maturity)_{it} = a + Avg_temperature_{it-1} + Avg_temperature_{it-1} \times CPU_{t-1} + ROA_{it-1} + Size_{it-1} + Cash\ reserve_{it-1} + Q\ ratio_{it-1} + D/E\ ratio_{it-1} + LA\ ratio_{it-1} + currentratio_{it-1} + \lambda_i + \zeta_t + \varepsilon \quad (3)$$

Column 2 of Table 3 shows the interaction term $Avg_temperature_{it-1} \times CPU_{t-1}$ is statistically significant and negatively related to Log(Maturity) at 1% level (coefficient = -0.0830, t-value= -2.75). This suggests that rising uncertainty surrounding climate-related regulations and policies amplifies firms' tendency to issue shorter-term debt in response to high-temperature risks, prioritizing financial flexibility.

To ensure robustness, an alternative measure of economic uncertainty—the debt ceiling relative frequency data—is employed. This variable captures the number of times the "debt ceiling" is mentioned in U.S. newspapers, sourced from Access World News' NewsBank service, and is divided by the total number of news articles in each month.[21] To align with the scale of other independent and dependent variables, the ratio is multiplied by 1000. The model in Equation (3) is re-estimated, replacing CPU with DebtCeilingRFreq. The interaction term $Avg_temperature_{it-1} \times DebtCeilingRFreq_{t-1}$ is statistically significant and negatively related to Log(Maturity) at 1% level (coefficient= -0.0410, t-value=-2.62). This further reinforces the conclusion that firms increasingly rely on shorter-term debt issuance when facing heightened economic uncertainty and temperature risks simultaneously.

[20] The CPU index by Gavriilidis (2021) ranges from 28.16 to 411.28. Thus, to match the scale of Avg_tempearture and Log(Maturity), I scale CPU by 100. See https://www.policyuncertainty.com/climate_uncertainty.html.

[21] See https://www.policyuncertainty.com/categorical_epu.html.

4.2.3 Time Trend Analysis

To examine how the term structure evolved over the sample period and whether overall debt maturity changed over time, a time trend variable (incrementing by 1 each quarter) is introduced and interacted with average temperature, following Gounopoulos and Zhang (2024).[22] The time trend accounts for potential shifts in new debt maturity decisions that may occur due to factors unrelated to the temperature risk. Replacing CPU in Equation (3) with Time_Trend and incorporating firm and time-fixed effects, the model tests whether the impact of temperature on new debt issuance maturity has changed over time. The interaction term $Avg_temperature_{it-1} \times Time_Trend_{t-1}$ in Column 3 of Table 3 is negative and statistically significant at the 1% level (coefficient = -0.0594, t-value = -2.4). This suggests that the influence of temperature on new debt maturity has intensified over time. Firms are increasingly adjusting their debt structures in response to rising temperature risks.

[Table 3 here]

4.3. Dependence on Size, Industry Vulnerability, Geographic Region, and Financial Constraints

Given the observed negative impact of high-temperature risks on debt maturity, I delve into how this effect varies with firm characteristics. It is anticipated that firms facing high-temperature risks often experience increased uncertainty and production disruptions. This effect is likely more pronounced among riskier firms with limited resources to mitigate climate challenges, such as those with higher financial constraints, greater leverage, hailing from vulnerable industries, and stricter regions. The baseline regression model (Equation 1) is used for subsample analyses based on firm size, vulnerable and non-vulnerable industries, and lastly, strict and lenient regions.

4.3.1. Subsample Analysis: Small vs. Large Firms

[22] A time trend variable is typically modeled as a linear function of time, increasing incrementally throughout the sample period. By incorporating a time trend and interacting it with average temperature, this approach captures how the relationship between temperature and debt maturity has evolved. This method controls for broader market-wide changes in debt maturity, isolating the impact of temperature risk from general economic trends.

A subsample analysis of "small" firms is conducted to understand how high-temperature risk influences the maturity of new debt issues. The "small firms" are defined as those whose natural logarithm of total assets falls below the 25th percentile of the overall firm size distribution. The same equation as presented in Equation (1) is employed. The regression results for the effect of high-temperature risk on Log(Maturity) for small firms are displayed in Column 1 of Table 4.

In Column 1, small firms exhibit an insignificant negative relationship between newly issued debt maturity and lagged average temperature (Avg_temperature). A ten-degree Fahrenheit increase in temperature reduces Log(Maturity) by 0.47%, though not significantly. This suggests that while smaller firms may prefer shorter-term debt for flexibility, their localized operations, limited bargaining power, and constrained market access compel them to offer longer maturities to attract creditors, even under similar high-temperature risks. Unlike larger firms with broader geographic exposure and greater operational complexity, small firms experience less direct impact from temperature variations.

Next, a subset of large firms to explore how high-temperature risks affect new debt maturity is analyzed. 'Large firms' are defined as those with total assets exceeding the 75th percentile of the overall distribution, using the natural logarithm. This analysis utilizes the same equations as the one used for small firms (same as Equation 1) and the regression results for the effect of high-temperature risk on the Log(Maturity) of large firms are displayed in Column 2 of Table 4.

For larger firms, a 10°F increase in average temperature reduces Log(Maturity) by 5.8%, significant at the 5% level. This means that for a 10°F increase in Avg_temperature, the original debt maturity decreases by approximately 5.63%. If the original maturity is 10 years, the decrease would be 6.76 months. These firms, facing greater regulatory scrutiny and reputational risks, issue shorter-term debt to enhance financial flexibility and signal strong risk management (Maksimovic & Titman, 1991). Despite their superior capital access, heightened regulatory demands and the need to signal quality drive them toward shorter maturities as a precautionary measure (e.g., Flannery (1986); Diamond (1991); Kale and Noe (1990)). Moreover, larger firms operate across multiple regions, exposing them to varying climate conditions, which amplifies their

sensitivity to temperature risks. This geographic diversification leads to a strategic focus on short-term debt to manage diverse environmental risks while aligning with CSR and ESG goals, positioning them favorably with investors and policymakers.

Firm size is an indicator of financial health, capturing the degree of constraints while also reflecting factors such as risk diversification, investor scrutiny, and strategic capital management. Hypothesis 2 examines the influence of financial constraints on debt maturity, whereas the size-based analysis accounts for multiple underlying dynamics. Firms facing financial constraints are compelled to issue short-term new debt due to borrowing limitations, whereas larger firms strategically opt for short-term debt to enhance flexibility and signal financial strength. Following Section 4.2.1, I conduct a Wald test for the two subsamples. The Wald test statistics is -1.77, statistically significant at 10%. Therefore, the difference between the large and small firm coefficients is statistically significant.

[Table 4 here]

4.3.2. Subsample Analysis: Vulnerable vs. Non-vulnerable Firms

The impact of high-temperature risks on the Log(Maturity) of firms operating in vulnerable and non-vulnerable industries is investigated. Firms are characterized as operating in vulnerable industries if they are in agriculture, mining, transportation, insurance, oil and gas, manufacturing, and real-estate industries as they are directly impacted by high-temperature risks, following Giglio et al. (2021); the rest are less directly affected (e.g., technology, healthcare, pharmaceuticals, grocery industry) and thus are classified as firms from non-vulnerable industries. Using the first 2-digits of the 4-digit SIC codes, the firms are assigned to vulnerable and non-vulnerable industry groups.

For firms operating in vulnerable industries, Column 1 of Panel A shows a ten-degree Fahrenheit increase in Avg_temperature decreases the Log(Maturity) by 4% (at a 1% significance level). This means that for a 10°F increase in Avg_Temperature, the original debt maturity decreases by approximately 3.92%, and if the original debt maturity is 10 years, the decrease would be 4.7 months. Column 2 of Panel A in Table 5 shows a significant negative correlation at a 10% significance level between Log(Maturity) and

Avg_temperature for firms in non-vulnerable industries. For a ten-degree Fahrenheit increase in Avg_temperature, the Log(Maturity) decreases by 3.85%. Thus, a 10°F increase in Avg_Temperature leads to an approximate 3.78% decrease in original maturity, and for a 10-year loan, a 10°F increase in temperature reduces the maturity by approximately 4.54 months. This aligns with Manuelli (2019) that firms operating in more volatile environments issue shorter-term debt. So, firms in vulnerable industries tend to issue shorter-term loans than firms in non-vulnerable industries, although both groups reduce the maturity of newly issued debt in response to high-temperature risks.

To confirm this and to tackle endogeneity concerns, a PSM analysis has been done where vulnerable industry firms are in the treatment group (1) and non-vulnerable industry firms are in the control group (0). I use nearest-neighbor matching with firm size, D/E ratio, ROA, and industry as matching variables to standardize values for comparability. Distances between observations in treatment and control groups are calculated based on these covariates to identify nearest neighbors. Pairs are formed to create a matched dataset, ensuring covariate balance is checked. A balancing test confirms that after matching, the covariate distributions between treated and control groups are statistically indistinguishable, strengthening the assumption of conditional independence.[23] Panel B of Table 4 shows the result of the PSM analysis. The difference in the mean Log(Maturity) is 0.0809, meaning that firms in vulnerable industries tend to issue shorter-term debt than non-vulnerable industry firms. The t-test shows a t-value of 3.09 and a p-value of 0.002, which is statistically significant at the 1% level. So, vulnerable firms issue shorter-term debt than firms in less vulnerable industries, potentially as a strategy to mitigate high-temperature risks and the heightened uncertainties associated with their industry.

Firms in vulnerable industries often face higher borrowing costs due to perceived risks, driven by significant capital expenditure needs and operational demands. Lenders demand a premium for long-term debt, as these firms are viewed as more likely to default, given environmental and regulatory challenges. This results in higher interest rates and increased interest expenses relative to assets or revenues, reflecting the market's

[23] Following Rubin (2001), in untabulated results, I confirm that B = 4.92 (below 25) and R = 0.81 (between 0.5 and 2), indicating a good balance.

risk assessment. To mitigate these costs, vulnerable firms—characterized by a higher interest expense ratio (IER)—tend to issue shorter-term debt than their non-vulnerable counterparts, especially amid high-temperature risks. To model how IER impacts Log(Maturity), the following equation is used:

$$Log(Maturity)_{it} = a + IER_{it-1} + ROA_{it-1} + Size_{it-1} + Cash\ reserve_{it-1} + Q\ ratio_{it-1} + D/E\ ratio_{it-1} + AL\ ratio_{it-1} + Currentratio_{it-1} + \lambda_i + \zeta_t + \varepsilon \quad (4)$$

Panel A, Column 3 of Table 5 reveals a significant negative relationship between IER and Log(Maturity), indicating that as the IER increases, the maturity of newly issued debt tends to shorten significantly at the 1% level. A 10°F increase in temperature results in an approximate 8.8% decrease in the original maturity of the debt, and for a 10-year loan, a 10°F increase in temperature would reduce the maturity by about 0.88 years or 10.56 months. To examine how Log(Maturity) changes for firms in vulnerable industries with higher IER, the following model is used:

$$Log(Maturity)_{it} = a + IER_{it-1} + IER_{it-1} \times vulnerable_i + ROA_{it-1} + Size_{it-1} + Cash\ reserve_{it-1} + Q\ ratio_{it-1} + D/E\ ratio_{it-1} + AL\ ratio_{it-1} + currentratio_{it-1} + \lambda_i + \zeta_t + \varepsilon \quad (4)$$

Column 4 reinforces the previous findings, showing that IER alone exhibits a negative relationship with Log(Maturity) at the 5% significance level. This underscores the effect of IER independent of other factors. Additionally, a significant negative relationship is found between the vulnerable industry dummy (which assigns a value of 1 to firms in vulnerable industries and 0 otherwise) and Log(Maturity), suggesting that firms in vulnerable industries tend to issue debt with shorter maturities. The interaction term between IER and the vulnerable industry dummy is also statistically significant and negatively associated with Log(Maturity). This indicates that the higher IER among vulnerable firms leads to shorter debt maturities than expected based on their financial constraints and high-temperature risks. This finding suggests that while firms in vulnerable industries issue shorter-term debt due to elevated interest expenses, the intensity of this response is moderated by their IER obligations.

A propensity score matching (PSM) test is conducted to compare IER between vulnerable and non-vulnerable industries, with nearest-neighbor matching, and firm size, D/E ratio, current ratio, and industry as

matching variables. Vulnerable firms comprise the treatment group, and non-vulnerable firms form the control group. Panel C of Table 5 shows a mean IER difference of 0.01 (IER is in ratio form), with a statistically significant negative t-test result (t-value: -5.98), confirming that vulnerable firms face a higher interest expense ratio. Issuing shorter-term loans and reducing overall debt maturity due to temperature risks, helps these firms stabilize cash flows, and balance out the higher interest expenses.

[Table 5 here]

4.3.3. Subsample Analysis: Firms in Strict vs. Lenient Regions

For this analysis, firms are categorized by geographical locations (primarily U.S. states) of their headquarters into those operating in strict versus lenient regulatory environments regarding climate-related policies. Stricter states include NY, WA, CA, NV, OR, CO, UT, AZ, NM, TX, LA, FL, GA, SC, NC, IA, IL, MN, WI, MI, OH, PA, MD, VT, NH, ME, MA, CN, NJ, RI, and DE.[24] The remaining states are considered lenient. Firms in states with stricter environmental regulations tend to issue more short-term debt in response to high-temperature risks.

Stricter policies and regulations introduce uncertainty around compliance costs, potential fines, and future policy changes. As a result, firms are hesitant to issue long-term debt due to the unpredictable expenses associated with adapting to new regulations. Instead, they opt for shorter-term debt, which provides flexibility to adjust their capital structure as conditions evolve and high-temperature risk rises. In stricter regions, firms also face pressure to invest in ESG or CSR activities, such as cleaner technologies and emissions reductions, which divert capital from long-term projects. Short-term debt helps balance these investments with financial obligations and react to impending high-temperature risks, offering flexibility to manage any cash flow volatility introduced by regulatory changes. Stricter regulations make long-term investment returns less predictable, causing firms to avoid long-term debt commitments when the future of their operations,

[24] State Climate Policy Tracker: https://climate-xchange.org/dashboard/map/.

profitability, and climate risks is uncertain. Short-term debt enables these firms to maintain financial flexibility while adapting to evolving regulatory environments and addressing physical risks from rising temperatures.

In Column 1 of Panel A in Table 6, for firms in strict regions, a ten-degree Fahrenheit increase in average temperature reduces Log(maturity) by 2.72%, a statistically significant result at the 1% level. Thus, for a 10°F increase in Avg_temperature, the original debt maturity decreases by approximately 2.68%, and if the original debt maturity is 10 years, the reduction is 3.22 months for firms in the stricter region. In Column 2 of Panel A, firms in lenient states experience a 1.07% reduction in Log(maturity) with a ten-degree temperature increase, though the relationship is insignificant (a 10°F increase in Avg_temperature corresponds to a 1.07% decrease in original maturity, and if the original maturity is 10 years, the change in maturity would be 1.28 months). This suggests that firms in lenient states, facing less regulatory pressure and scrutiny, make fewer substantial adjustments to their debt maturity in response to temperature risks.

A subsample has been created with firms in both vulnerable industries and strict regions, using Equation 1. The results are shown in Column 3 of Panel A in Table 6. For firms in vulnerable industries located in stricter regions, a ten-degree Fahrenheit increase in average temperature results in an 18% decrease in Log(Maturity), a 16.5% decrease in original maturity, and if the original maturity is 10 years, the change in years would be 1.65 years, significant at the 10% level. So, these firms, facing more pressure and risks, issue shorter-term debt at a higher rate.

To validate the robustness of the findings of Columns 1 and 2 of Panel A in Table 6, a PSM analysis was conducted (see Panel B of Table 6) to assess the difference in mean Log(Maturity) between firms located in strict and lenient regions. This also serves concerns regarding potential endogeneity issues. Firms operating in stricter regions are classified as the treatment group, while those in lenient regions serve as the control group. The difference in the mean Log(maturity) between firms in lenient (0) and strict (1) regions is 0.0187. This indicates that, on average, firms in stricter regions issue shorter-term debt than those in more lenient regions, and the t-test shows the statistical significance (at a 10% level) of the difference (t-value= 1.87).

[Table 6 here]

4.3.4. Subsample Analysis: Financially Constrained Firms

Two subsample analyses are conducted to assess the impact of high temperatures on Log(Maturity) for firms with higher financial constraints and leverage. The first analysis uses the liability-asset (LA) ratio, calculated by dividing total liabilities by total assets, as a proxy for financial constraint.[25] By understanding the proportion of assets financed by liabilities, stakeholders can gauge the company's risk level, investment potential, and financial health. Firms with quarterly LA ratios above the 50th percentile of the overall LA ratio distribution are included in this subsample. The second analysis employed the debt-to-equity (D/E) ratio as a proxy for leverage, including firms whose quarterly D/E ratios exceeded the 50th percentile of the overall D/E ratio distribution.

Conducted using the Equation (1) setup, the regression results are summarized in Table 7. In Column 1, for firms with high LA ratios (indicating greater financial constraints), a ten-degree Fahrenheit increase in average temperature leads to a 2.73% reduction in Log(Maturity), significant at the 5% level. This means that a 10°F increase in the average temperature leads to a 2.73% decrease in the original maturity. In Column 2, for firms with high D/E ratios (highly leveraged), the same increase in temperature results in a 3.15% decrease in Log(Maturity), and a 3.1% decrease in original maturity, significant at the 1% level. If the original maturity is 10 years, the decrease in maturity would be 3.72 months.

In Columns 3 and 4, I interact the debt-to-equity ratio and the liability-to-asset ratio with Avg_temperature as a robustness check.[26] In Column 3, the interaction term Avg_temperature × DE_ratio is statistically significant and negative (coefficient= 0.0108, t-value= -2.54). In Column 4, the interaction term Avg_temperature × LA_ratio is also statistically significant and negative at 1% level (coefficient= -0.0150, t-value= -2.59). These findings indicate that financially constrained and highly leveraged firms experience a significant reduction in the maturity of new debt issuance as temperatures rise.

[25] A higher liability-asset ratio indicates that a greater proportion of a company's assets are funded by debt. This situation suggests that the firm is more leveraged, which can limit its financial flexibility and increase risk.

[26] Interaction terms allow for a more continuous and flexible assessment of how these characteristics influence the effect of temperature on new debt maturity.

[Table 7 Here]

4.4. Matching Analysis Based on High and Low-Temperature Risks

The matching analyses in this section aim to understand how firms with similar characteristics exhibit variations in newly issued debt maturity structures under different levels of temperature risk. This paper uses the nearest-neighbor matching (NNM) method which effectively addresses endogeneity concerns by mitigating selection bias in the estimation process, thereby reducing issues related to observable confounders. The treatment group, comprising firms in the top 75th percentile of average temperature exposure, is compared with a control group from the bottom 25th percentile. Dummy variables for high and low-temperature risks are defined as 1 and 0 respectively, with firm size, ROA, and industry as matching variables to standardize values for comparability in one test, and firm size, current ratio, and industry as matching variables in another.

Distances between observations in treatment and control groups are calculated based on these covariates to identify nearest neighbors for both tests. Pairs are formed to create a matched dataset for both tests, ensuring covariate balance is checked. A subsequent t-test compares the natural logarithm of new debt issues between high and low-temperature-risk groups to assess statistical significance.

The results in Panel A of Table 8 of the first test (industry, current ratio, and size as matching variables) show statistically significant differences in the mean logarithm of new debt maturity between high and low-temperature-risk groups. In this test, firms in the high-temperature group have a mean Log(Maturity) of 2.26, while those in the low-temperature group have a mean Log(Maturity) of 2.31. The difference in means is 0.048, indicating that firms in the high-temperature group have a significantly lower Log(Maturity) than their counterparts in the low-temperature group. The results are statistically significant, with a t-value of 2.96 and a p-value of 0.003, suggesting a robust difference between the two groups. The two groups have equal variances (F Value = 1.01, p-value = 0.847), supporting pooled variance in the t-test, which shows econometric soundness. This reinforces the conclusion that temperature impacts the maturity structure of firms' debt.

The second matching analysis comparing firms in high and low-temperature groups regarding Log(Maturity) provides insights into the impact of temperature on debt maturity while controlling for size,

return on assets (ROA), and industry characteristics in Panel B of Table 8. The mean Log(Maturity) for firms in the low-temperature group (0) is 2.3195, while for the high-temperature group (1), it is 2.269. The difference in means between the two groups is 0.0497, suggesting that firms in the high-temperature group have a significantly lower Log(Maturity) by this amount compared to those in the low-temperature group. The t-value of 3.04 and the p-value of 0.002 indicate that the observed difference in Log(Maturity) is statistically significant at a 1% significance level. The analysis shows that the variances of the two groups are equal (F Value = 1.01, p-value = 0.786). The analyses effectively control for potential confounding factors, reinforcing the conclusion that higher temperatures are associated with a reduction in the maturity of new debt issuance.

[Table 8 here]

4.5. Impact of Credit Ratings on Log(Maturity) Amid Higher Temperature Risk

This section investigates the relationship between the S&P quality rankings, temperature exposure, and the maturity of newly issued corporate debt. To explore this, I first examine the interaction between the temperature risk (Avg_temperature) and the S&P quality ranking. The S&P Quality Ranking, categorized into eight groups, is used to measure the overall creditworthiness of firms. The eight categories are converted into rank scores from 1 to 8, where higher ranks represent higher creditworthiness. The ranks are then used to analyze their influence on the Log(Maturity). Additionally, the effect of these rankings is also assessed in isolation. The following equation is used:

$$Log(Maturity)_{it} = a + Avg_temperature_{it-1} + Avg_temperature_{it-1} \times S\&PQualityRank_{it-1} + S\&PQualityRank_{it-1} + ROA_{it-1} + Size_{it-1} + Cash\ reserve_{it-1} + Q\ ratio_{it-1} + DEratio_{it-1} + AL\ ratio_{it-1} + currentratio_{it-1} + \lambda_i + \zeta_t + \varepsilon \quad (5)$$

First, the interaction between the S&P Quality Ranking and avg_temperature on the log of debt maturity (Log(Maturity)) is examined. In Table 9 Column 1, the interaction term between the S&P quality ranking and average temperature yields a reduction in Log(maturity) of 1.517%, which is statistically significant at the 10% level. This means that for a 10°F increase in temperature, the maturity will decrease by approximately 1.49%, and if the original maturity is 10 years, the decrease in maturity would be 1.79 months.

This suggests that, as firms experience higher temperatures, their credit rating quality interacts with this risk of influencing their debt maturity decisions. Specifically, firms with higher credit ratings appear to issue slightly longer-term debt in response to higher temperatures, indicating that higher-quality firms may have more flexibility in adjusting their debt structure despite the challenges posed by temperature risks.

The standalone effect of the S&P Quality Ranking reveals a statistically significant positive relationship with Log(Maturity), indicating that firms with higher credit ratings tend to issue longer-term debt, due to their perceived lower risk of default. This result highlights the importance of creditworthiness in shaping debt maturity decisions. In contrast, the average temperature (avg_temperature) exhibits a statistically significant negative relationship with Log(Maturity), suggesting that higher temperatures are associated with shorter debt maturities. Together, these results underline the differential influence of credit ratings and temperature exposure on debt maturity, with credit quality driving firms toward longer-term debt issuance, while temperature risks push firms to shorten debt maturities.

To further investigate the impact of credit ratings on the relationship between temperature and debt maturity, the sample is divided based on the S&P long-term issuance ranking, which contains 21 categories. This serves as an additional indicator of the firm's long-term debt standing and is converted into numerical ranks, with higher values corresponding to better ratings. Firms with a ranking of 10 or lower are classified as having poor credit ratings, while firms with a ranking of 16 or higher are considered to have good credit ratings.

The setting of Equation 1 is used for subsample analyses. For the subsample of firms with poor credit ratings (rank $\leq$ 10), the analysis reveals a statistically significant negative relationship between average temperature (avg_temperature) and Log(Maturity). Specifically, in Table 9 Column 2, the log(maturity) reduces by 23%, significant at the 1% level, indicating that higher temperatures are associated with shorter debt maturities for firms in this category. This result suggests that firms with poorer credit ratings, facing greater financial constraints, tend to reduce debt maturity as a strategy to mitigate the risks posed by higher temperatures. This aligns with the credit rationing theory (Stiglitz & Weiss, 1981), where firms with weaker credit profiles face more stringent borrowing constraints, making them more reactive to environmental risks.

Conversely, for the subsample of firms with good credit ratings (rank ≥ 16), the relationship between avg_temperature and Log(Maturity) is significantly positive in Table 9 Column 3. The coefficient of 0.032, significant at the 5% level, indicates that for firms with better credit ratings, higher temperatures are associated with slightly longer debt maturities. Specifically, a 10°F increase in temperature is associated with a 3.25% increase in the original maturity. This suggests that these firms, with relatively lower perceived risk, may not face the same financial pressures as their poorer-rated counterparts, and thus they exhibit a preference for longer-term debt issuance despite rising temperature risks. These findings highlight the differential effects of credit ratings on the temperature-maturity relationship, demonstrating that firms with lower credit ratings are more likely to shorten debt maturities in response to high temperatures, while those with higher ratings exhibit the opposite tendency.

[Table 9 here]

4.6. Placebo Test

To assess the robustness of the results and ensure that the observed relationship between temperature risk and newly issued debt maturity is not driven by spurious factors, a placebo test is conducted. In this test, a random variable, AvgTemperaturePlacebo, is generated by randomly assigning values to mimic the structure of Avg_temperature but without any actual connection to temperature data. This random variable serves as a null predictor in place of Avg_temperature to evaluate whether the relationship found in the main analysis holds when no true effect is present.

The placebo test is performed by running the same regression model (as specified in Equation 1) with AvgTemperaturePlacebo replacing Avg_temperature. The results, presented in Table 10, Column 1, show that AvgTemperaturePlacebo does not exhibit any significant relationship with Log(Maturity). The coefficient for AvgTemperaturePlacebo is -0.0021, with a t-value of -0.26, which is statistically insignificant. This lack of significance provides strong evidence that the relationship observed in the main analysis is not due to chance or a spurious correlation. The placebo test, therefore, reinforces the validity of the original findings, confirming that the impact of Avg_temperature on Log(Maturity) is unlikely to be driven by random factors.

4.7. Difference-in-differences Analysis- A Case of Florida

Florida, located along the southeastern coast of the United States, is highly susceptible to hurricanes. Defined by the Florida Climate Center (FCC) as tropical cyclones with sustained winds of at least 64 knots (74 mph), hurricanes are classified using the Saffir-Simpson Hurricane Wind Scale based on factors like wind speed, central pressure, and storm surge height.[27] Florida faces this threat notably during the six-month Atlantic hurricane season from June 1 to November 30. Data analysis shows a significant absence of major hurricanes in Florida from 2006 to 2015, but from 2016 to 2022, the state experienced several devastating hurricanes, with high impacts according to the scale. In this analysis, hurricanes act as exogenous shocks—external factors beyond the control of economic agents. This paper identifies the period from 2016 to 2022 in Florida as marked by climate risk.

To address endogeneity in the study of debt maturity and climate risk, this paper employs a difference-in-differences (DiD) framework- a robust method for evaluating causal effects, using the case of Florida.[28] The analysis focuses on the impact of climate shocks by introducing a binary variable, "HurricaneYears," which is set to 1 for the period from 2016 to 2022—reflecting the elevated climate risk in Florida during these years—and 0 for the pre-2016 period. "HurricaneYears" interacts with climate risk measures to capture the differential impact of increased climate risk on debt maturity specifically during the high-impact hurricane years.

Firms are categorized into high and low-temperature risk groups using a 50th percentile cutoff of Avg_temperature. A dummy variable, 'HighTempRisk,' is assigned a value of 1 if a firm's headquarters state's Avg_temperature exceeds this cutoff, and 0 otherwise. Each high-temperature risk firm is then matched with a low-temperature risk firm within the same industry to ensure comparability in relevant characteristics. The analysis spans from 2006 to 2022, covering both pre- and post-2016 periods to assess the effects of hurricanes that impacted Florida from 2016 to 2022. By comparing firms with very high and very low-temperature risks

[27] The Florida Climate Center website provides comprehensive information regarding significant hurricanes that impacted Florida from 1926 to 2022. All the relevant data can be accessed through the following link: https://climatecenter.fsu.edu/topics/hurricanes

[28] The paper utilizes a Difference-in-Differences (DiD) approach on Florida firms during hurricane-prone quarters to distinguish short-term temperature shocks from long-term risks. However, hurricanes introduce effects such as insurance adjustments, supply chain disruptions, and temporary financial shocks. Although unreported, a robustness check excluding hurricane-affected quarters confirms that the primary results remain qualitatively unchanged.

before and after the 2016 surge in hurricane activity, the study effectively isolates the impact of increased hurricane frequency on corporate debt maturity decisions. In the regression model, firm size, leverage, and return on assets (ROA) are included as matching variables to control for potential confounding factors. The model is as follows:

$$Log(Maturity)_{it} = a + HurricaneYears_{t-1} \times HighTempRisks_{it-1} + HighTempRisks_{it-1} + Controls_{it-1} + \lambda_i + \zeta_t + \varepsilon \quad (6)$$

Table 10 Column 2 shows the results of the model. The interaction term is negative and statistically significant at the 5% level, with a coefficient of -0.1639, indicating that the combined effect of HurricaneYears and HighTempRisk reduces the Log(Maturity) by 16.39%, approximately 15.2% decrease in the original maturity. The significance of $\text{HighTempRisks}_{it-1}$ suggests that the hurricane-prone years (2016-2022) are associated with shorter debt maturities. This finding highlights the potential long-term impact of temperature risks on firms' debt structuring decisions.

4.8. Additional Robustness Check- Using Untransformed New Debt Issuance Maturity

The paper mainly uses Log(Maturity) rather than untransformed maturity to handle the skewness and heteroskedasticity commonly associated with debt maturity data, following Brockman et al. (2010) and Huang et al. (2023). The distribution of maturity values is highly skewed to the right, as depicted in Figure 1, with a few firms issuing significantly longer-term debt, which can disproportionately influence the results. Using the log transformation normalizes the distribution, stabilizes variance, and leads to more robust regression estimates. While using untransformed maturity could provide alternative insights, Log(Maturity) allows for a clearer interpretation and better statistical properties.

To address potential concerns, I conduct a robustness check using the weighted average untransformed maturity of new debt issuance as the dependent variable, against both Avg_temperature and Temperature_volatility, to verify whether the main results hold under alternative specifications. I use the model depicted in Equation (1), replace Log(Maturity) with Maturity, and report the result on Panel C of Table 10.

Panel C, Column 1 shows for a 10-degree Fahrenheit increase in average temperature, the untransformed maturity decreases by 0.00152 years. Column 2 shows for each 10-unit increase in the 4-quarter rolling standard deviation of average temperature (in Fahrenheit), the untransformed maturity increases by 0.00081 years. The regression results using untransformed maturity show statistically significant coefficients, albeit with smaller magnitudes compared to those obtained using Log(Maturity). This suggests that while the relationship between temperature risk and debt maturity persists, the untransformed maturity data may not fully capture the intensity of the effect due to its skewed distribution. As a result, the Log(Maturity) model is preferred in this study, as it provides more robust and interpretable results, reflecting the percentage change in debt maturity more clearly. Nevertheless, the consistency of the findings across both model specifications supports the robustness of the main conclusions.

[Figure 1 and Table 10 here]

6. Conclusion

This paper examines how temperature risk influences corporate new debt issuance maturity, focusing on persistent temperature exposure. Results further show that both rising average temperatures and increased temperature variability (short-term temperature shocks) significantly shorten new debt issuance maturity, indicating that firms adjust their borrowing horizon in response to both long-term warming trends and immediate temperature fluctuations. The paper proves that firms' strategic debt issuance decisions are more closely aligned with persistent temperature risks rather than temporary fluctuations. Further analysis of the term structure reveals that the impact of temperature risk on new debt issuance maturity has intensified over time, suggesting an evolving corporate response to temperature-related financial risks. This study also highlights significant differences in behavior between firms in strict versus lenient regulatory environments and those classified as vulnerable and financially constrained. The findings demonstrate that rising temperatures correlate with shorter debt maturities, particularly for firms in stricter regions and those operating in vulnerable industries. The analysis suggests that as firms face heightened temperature risks and regulatory scrutiny, they issue shorter-term debt to maintain flexibility amid uncertainty.

The results indicate that firms in strict regulatory regions experience a more pronounced response to temperature changes, with a notable reduction in the Log(Maturity) of newly issued debt. Conversely, firms in lenient regulatory environments exhibit less sensitivity, reflecting varying levels of pressure from regulatory frameworks. Additionally, while both vulnerable and non-vulnerable firms issue shorter-term debt in response to heightened temperature risk, vulnerable firms tend to issue debt with slightly longer maturities than their non-vulnerable counterparts. This distinction is further underscored by the fact that vulnerable firms incur higher interest expense ratios (IER) compared to non-vulnerable firms. The positive relationship between IER and Log(Maturity) indicates that as financial pressures increase, firms may issue debt with longer maturities, to manage the higher costs of borrowing. Moreover, the analysis highlights that financially constrained and highly leveraged firms are particularly susceptible to rising temperatures. Significant reductions in Log(Maturity) associated with increased average temperatures suggest that these firms prioritize financial flexibility amid climate uncertainty. Furthermore, higher credit ratings give firms the liberty to have longer-duration debts, they adjust their debt decision as they have a better reputation. On the other hand, firms with poor credit ratings issue shorter-term debt at a higher level given higher temperature risk.

Overall, this research contributes to the growing body of literature on climate finance by illuminating how environmental factors influence corporate financing strategies. The implications extend to policymakers and corporate managers, emphasizing the need for adaptive strategies in the face of climate change. As temperature-related risks continue to escalate, firms must navigate the complexities of financial decision-making to ensure sustainable growth and resilience in an increasingly uncertain climate landscape. Future research should explore the long-term consequences of these shifts in debt maturity on corporate performance and stability in the context of ongoing climate change challenges, and how regulatory frameworks influence firms' debt maturity decisions in response to other climate risks. Additionally, studying the effectiveness of risk mitigation strategies like insurance instruments and sustainability investments in influencing debt maturity choices could provide practical implications for policymakers and practitioners alike.

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Table 1: Summary statistics and Pearson's correlation

Panel A: Summary Statistics

Variables	*Mean*	*Std Deviation*	*Max*	*N*	*Range*
Log(Mat)	0.957	0.377	1.699	8,779	1.336
Maturity	11.634	6.66	35.33	8,779	32.31
AvgTemp	55.59	15.76	94.36	8,779	85.8
ROA	0.026	0.021	0.093	8,779	0.111
Cash_reserve	0.093	0.102	0.826	8,779	0.825
ALratio	0.362	0.213	2.258	8,779	2.247
inc2Sales	6.191	1.765	10.50	8,779	14.63
CPU	131.511	64.907	336.78	8,779	308.61
DebtCeiling	0.52	1.681	12.549	8,779	12.543
TempVolat	1.271	0.323	2.424	8,779	1.958
DEratio	1.457	6.052	33.611	8,779	60.373
LAratio	0.359	0.204	0.992	8,779	0.971
Qratio	1.691	0.964	6.211	8,779	5.372
size	4.344	0.833	6.484	8,779	3.764
currRatio	0.919	1.027	5.635	8,779	5.561
CPU	127.33	67.14	411.28	257	383.12

Panel B: Pearson's Correlation

Variables	*Maturity*	*STI*	*AL ratio*	*Temp Voal*	*Avg Temp*	*Log(Mat)*	*CPU*	*Debt Ceiling*	*Cash Rsrv*	*Inc2 Sales*	*Avg Price*	*Q ratio*	*size*	*ROA*	*DE ratio*	*Curr Ratio*
Maturity	1															
STI	-0.114	1.000														
ALratio	-0.053	0.308	1.000													
TempVolat	-0.040	-0.026	-0.041	1.000												
AvgTemp	-0.039	0.000	-0.040	0.316	1.000											
Log(Mat)	0.949	-0.136	0.036	-0.040	-0.029	1.000										
CPU	-0.058	0.012	0.162	0.068	0.017	-0.036	1.000									
DebtCeiling	-0.018	-0.019	-0.061	0.051	0.036	-0.009	-0.046	1.000								
cashRsrv	-0.034	0.157	-0.115	-0.010	-0.048	-0.002	0.057	0.020	1.000							
Inc2Sales	0.202	0.502	0.044	0.001	-0.009	0.202	-0.016	0.044	0.059	1.000						
avgPrice	0.017	0.105	0.001	-0.011	-0.019	0.029	0.137	-0.026	0.120	0.130	1.000					
Qratio	0.002	-0.017	0.125	-0.025	-0.043	0.016	0.090	-0.045	0.354	0.079	0.355	1.000				
size	0.191	0.591	0.092	-0.011	-0.005	0.192	0.016	0.038	-0.026	0.922	0.090	-0.104	1.000			
ROA	0.036	0.116	0.030	0.027	0.007	0.033	-0.067	0.004	0.253	0.179	0.097	0.577	-0.164	1.000		
DEratio	-0.009	-0.152	-0.060	-0.006	-0.030	-0.008	-0.012	0.003	-0.010	-0.025	0.015	0.017	-0.056	0.036	1.000	
CurrRatio	0.012	0.108	-0.074	-0.004	-0.015	0.002	0.066	0.014	0.402	-0.180	0.010	0.118	-0.215	0.099	-0.029	1

Table 1 presents the summary statistics and Pearson's Correlation among the variables employed in the research and regression analysis. It provides an overview of the key statistical measures, such as means, standard deviations, and minimum and maximum values, as well as the correlation among the variables utilized in the study.

Table 2: Effect of average temperature on newly issued debt maturity Log(Maturity) and short-term investment ratio (STI).

Variables	Log(Maturity)	Log(Maturity)	Variables	STI	STI
	(1)	(2)		(3)	(4)
Avg_temperature $_{it-1}$	-0.0212***	-0.0174**	**Avg_temperature**$_{it-1}$	0.0263*	0.0551***
	(-2.72)	(-2.28)		(1.88)	(9.37)
ROA $_{it-1}$	1.0527	1.7146***	**ROA**$_{it}$	3.1881***	8.2540***
	(1.60)	(4.01)		(2.78)	(13.19)
DE_ratio $_{it-1}$	-0.0007	-0.0008*	**DE_ratio**$_{it}$	-0.0001	-0.0003***
	(-1.53)	(-1.89)		(-0.22)	(-3.91)
cash_reserve $_{it-1}$	-0.3722**	-0.4461***	**cash_reserve**$_{it}$	8.4289***	2.9314***
	(-2.11)	(-4.87)		(28.67)	(24.70)
Size $_{it-1}$	-0.1353**	0.0759***	**size**$_{it}$	2.3210***	0.1413***
	(-2.58)	(6.15)		(19.72)	(8.13)
Q_ratio $_{it-1}$	0.0284*	0.0054	**Q_ratio**$_{it}$	0.0202	0.0598***
	(1.76)	(0.63)		(0.77)	(4.55)
LA_ratio $_{it-1}$	-0.1979**	-0.1888***	**LA_ratio**$_{it}$	-0.1159	-1.3901***
	(-2.15)	(-4.54)		(-0.67)	(-25.00)
Current_Ratio $_{it-1}$	0.0389***	0.0252***	**Current_Ratio**$_{it}$	0.0184	
	(3.85)	(3.28)		(1.49)	
Adj. R^2	0.3388	0.2529	**Adj. R^2**	0.9639	0.1032
Firm-fixed Effects	Yes	Yes	**Firm-fixed Effects**	Yes	Yes
Year-Quarter FE	Yes	Yes	**Year-Quarter FE**	Yes	Yes
Observations	7384	7384	**Observations**	7384	7384

Table 2 shows the results of dynamic panel regression on the maturity of newly issued debt and short-term investments. The dependent variable is the natural logarithm of newly issued debt maturity (Log(Maturity*)*) and the independent variables are the return on assets (ROA), debt-to-equity ratio as leverage measure, cash holdings, Tobin's Q ratio, liability-asset ratio (LA_ratio), and the size of the firm (natural logarithm of total assets). In the 2SLS model, the Avg_temperature$_{t-2}$ are used as instrument for Avg_temperature in time t-1. The average temperature is the main predictor. To improve interpretability, the average temperature is scaled by dividing by 10. As a result, the coefficient represents the effect of a 10°F increase in temperature on Log(Maturity). The independent and control variables are lagged by one-quarter for Log(Maturity), but not for STI. The standard errors have been clustered at the firm and time levels and fitted for heteroskedasticity. The coefficients of estimations are presented with ***, **, and * which show statistical significance at 1%, 5%, and 10% levels. The t-values are reported in parentheses. The t-statistics are adjusted for both heteroskedasticity and within correlations.

Table 3: Temperature shocks, policy uncertainty, and changes in term structure.

Variable	Temperature shock (1)	CPU (2)	Debt Ceiling (3)	Term Structure (4)
Avg_temperature $_{it-1}$		-0.0204**	-0.0331***	-0.3008***
		(-2.23)	(-2.65)	(-2.2)
Temperature_volatility $_{it-1}$	(-0.0052)**			
	(-2.22)			
Avg_temperature $_{it-1}$ **× Time_trend** $_{t-1}$				-0.0594***
				(-2.4)
CPU$_{t-1}$ **× Avg_temperature** $_{it-1}$		-0.0596***		
		(-2.75)		
DebtCeilingRFreq $_{t-1}$ **× Avg_temperature** $_{it-1}$			-0.0410***	
			(-2.62)	
ROA $_{it-1}$	1.0169	2.4188**	1.0563	1.1288
	(1.17)	(2.04)	(1.22)	(0.15)
cash_reserve $_{it-1}$	-0.0240***			
	(-3.75)			
Size $_{it-1}$	0.0486	2.2612***		0.0641
	(0.8)	(2.74)		(0.11)
Q_ratio $_{it-1}$	0.0051	0.0045	0.0047	0.0017
	(0.57)	(0.38)	(0.54)	(0.19)
AL_ratio $_{it-1}$	-0.1653***	-0.1983***	-0.1407***	-0.1162***
	(-4.01)	(-3.53)	(-3.45)	(-2.92)
Current_Ratio $_{it-1}$		-0.1603*	-0.0107*	-0.0137**
		(-1.83)	(-1.68)	(-2.15)
Income-to-sales $_{it-1}$	0.0188	0.0232	0.0176	0.0385
	(0.72)	(0.07)	(0.67)	(1.55)
DE_ratio $_{it-1}$		-0.0047	-0.0038	-0.0037
		(-1.31)	(-1.39)	(-1.47)
Adj. R^2	0.0193	0.0483	0.017	0.0204
Firm-fixed Effects	Yes	Yes	Yes	Yes
Year-Quarter Fixed Effects	Yes	Yes	Yes	No
Observations	6891	7384	7384	7384

Table 3 shows the impact of the temperature volatility (shock) on Log(Maturity) (Column 1), the interaction of average temperature and climate policy uncertainty (Column 2), the interaction of average temperature and debt ceiling frequency (Column 3), and the interaction between time trend variable and average temperature (Column 4). The independent variables are the return on assets (ROA), current ratio, debt-to-equity ratio as leverage measure, LA ratio, cash holdings, Tobin's Q ratio, and the firm's size (natural logarithm of total assets). To improve interpretability, the average temperature is scaled by dividing by 10. As a result, the coefficient represents the effect of a 10°F increase in temperature on Log(Maturity). The standard errors have been clustered at the firm and time levels and fitted for heteroskedasticity. The coefficients of estimations are presented with ***, **, and * which show statistical significance at 1%, 5%, and 10% levels. The t-values are reported in parentheses. The t-statistics are adjusted for both heteroskedasticity and within correlations.

Table 4: Impact of average temperature on Log(Maturity) of small vs. large firms.

Variable	Small Firms (1)	Large Firms (2)
Avg_temperature $_{it-1}$	-0.0047	-0.058**
	(-0.24)	(-2.53)
DE_ratio $_{it-1}$	-0.002	-0.0033
	(-0.49)	(-1.09)
ROA $_{it-1}$	0.117	1.9151
	(0.06)	(0.77)
cash_reserve $_{it-1}$	-0.1337	-0.2324
	(-0.22)	(-0.27)
Size $_{it-1}$	0.2027	-0.5962**
	(0.84)	(-2.04)
Q_ratio $_{it-1}$	0.0409	0.0239
	(0.57)	(0.33)
LA_ratio $_{it-1}$	-0.2875	-0.5244
	(-1.13)	(-1.33)
ROE $_{it-1}$	0.0121	0.0049
	(0.44)	(0.08)
Current_Ratio $_{it-1}$	-0.0204	-0.0291
	(-0.35)	(-0.29)
ROA $_{it}$	0.247	
	(0.17)	
DE_ratio $_{it}$	-0.0016	
	(-0.47)	
Q_ratio$_{it}$	0.0581	
	(0.99)	
Current_ratio$_{it}$	-0.0891*	
	(-2.04)	
Adj. R^2	0.7528	0.4713
Firm Fixed Effects	Yes	Yes
Year-Quarter Fixed Effects	Yes	Yes
Observations	1665	1668

Column 1 of Table 4 shows the impact of the average temperature on Log(Maturity) in small firms and Column 2 shows the effect on Log(Maturity) in large firms. The independent variables are return on assets (ROA), current ratio, debt-to-equity ratio as leverage measure, LA ratio, cash holdings, Tobin's Q ratio, and the firm's size (natural logarithm of total assets). To improve interpretability, the average temperature is scaled by dividing by 10. As a result, the coefficient represents the effect of a 10°F increase in temperature on Log(Maturity). The standard errors have been clustered at the firm and time levels and fitted for heteroskedasticity. The coefficients of estimations are presented with ***, **, and * which show statistical significance at 1%, 5%, and 10% levels. The t-values are reported in parentheses. The t-statistics are adjusted for both heteroskedasticity and within correlations.

Table 5: Effect of average temperature and interest expense ratio (IER) on newly issued debt maturity.

Panel A: Log(Maturity) of Vulnerable vs. Non-vulnerable Firms				
Variable	**Vulnerable (1)**	**Non-Vulnerable (2)**	**Log(Maturity) (3)**	**Interacting IER & Vulnerable (4)**
Avg_temperature $_{it-1}$	-0.0401*	-0.0383***		
	(-1.77)	(-2.99)		
IER $_{it-1}$			-0.0921***	15.088***
			(-3.85)	(2.35)
IER $_{it-1}$ × **Vulnerable**$_i$				-38.917*
				(-2.57)
Controls	Yes	Yes	Yes	Yes
Adj. R^2	0.3497	0.1795	0.1545	0.2332
Firm-fixed Effects	Yes	Yes	Yes	Yes
Year-Quarter Fixed Effects	Yes	Yes	Yes	Yes
Observations	4006	3378	7384	7384

Panel B: PSM Analysis of Log(Maturity) of Vulnerable vs. Non-vulnerable Firms				
Log(Maturity)	**Mean**	**Std Dev**	**t Value**	**Pr > |t|**
0 (Non-vulnerable)	2.365	0.4878		
1 (Vulnerable)	2.285	0.5196		
Diff (1-2): Pooled	0.0809	0.5163	3.09	0.002
Diff (1-2): Satterthwaite	0.0809		3.24	0.0013

Panel C: PSM Analysis of IER of Vulnerable vs. Non-vulnerable Firms				
IER	**Mean**	**Std Dev**	**t Value**	**Pr > |t|**
0 (Non-vulnerable)	0.052	0.036		
1 (Vulnerable)	0.062	0.045		
Diff (1-2): Pooled	-0.011	0.041	-5.98	<.0001
Diff (1-2): Satterthwaite	-0.011		-5.98	<.0001

Panel A of Table 5 shows the impact of the average temperature on Log(Maturity) in vulnerable industry firms (Column 1), non-vulnerable industry firms (Column 2), and the effects of IER on Log(Maturity) in Column 3 and Column 4. The independent variables are the return on assets (ROA), current ratio, debt-to-equity ratio as leverage measure, LA ratio, cash holdings, Tobin's Q ratio, and the firm's size (natural logarithm of total assets). To improve interpretability, the average temperature is scaled by dividing by 10. As a result, the coefficient represents the effect of a 10°F increase in temperature on Log(Maturity). The standard errors have been clustered at the firm and time levels and fitted for heteroskedasticity. The coefficients of estimations are presented with ***, **, and * which show statistical significance at 1%, 5%, and 10% levels. The t-values are reported in parentheses. The t-statistics are adjusted for both heteroskedasticity and within correlations. Panel B shows the PSM analysis on the maturity of newly issued debt of vulnerable vs. non-vulnerable industry firms. Panel C shows the PSM analysis of IER for vulnerable vs. non-vulnerable industry firms.

Table 6: Impact of average temperature on Log(Maturity) of firms in strict vs. lenient regions.

Panel A: Log(Maturity) of Firms operating in Strict vs. Lenient Region

Variable	Strict Region Firms (1)	Lenient Region Firms (2)	Strict Region and Vulnerable Industry Firms (3)
Avg_temperature $_{it-1}$	-0.0276***	-0.0111	-0.1812*
	(-3.09)	(-0.53)	(-1.81)
Controls	Yes	Yes	Yes
Adj. R^2	0.3453	0.3912	0.6246
Firm-Fixed Effects	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes
Observations	5288	2096	1771

Panel B: PSM Analysis of Log(Maturity) of Firms in Strict vs. Lenient Regions

Log(maturity)	Mean	Std Dev	t Value	Pr > |t|
0: Control group	2.4047	0.6317		
1: Treatment group	2.386	0.6426		
Diff (1-2): Pooled	0.0187	0.6412	1.84	0.075
Diff (1-2): Satterthwaite	0.0187		1.85	0.062

Panel A of Table 6 shows the impact of the average temperature on the Log(Maturity) of firms in strict region (Column 1), lenient region firms (Column 2), and while being in both strict region and vulnerable industry on Log(Maturity) in Column 3. The independent variables are the return on assets (ROA), current ratio, debt-to-equity ratio as leverage measure, LA ratio, cash holdings, Tobin's Q ratio, and the firm's size (natural logarithm of total assets). To improve interpretability, the average temperature is scaled by dividing by 10. As a result, the coefficient represents the effect of a 10°F increase in temperature on Log(Maturity). The standard errors have been clustered at the firm level and fitted for heteroskedasticity. The coefficients of estimations are presented with ***, **, and * which show statistical significance at 1%, 5%, and 10% levels. The t-values are reported in parentheses. The t-statistics are adjusted for both heteroskedasticity and within correlations. Panel B shows the PSM analysis on the maturity of newly issued debt of strict vs. lenient region firms.

Table 7: Effect of high-temperature risks on *Log(Maturity)* for firms with high financial constraints and leverage.

Variables	High LA_ratio	High DE_ratio	Overall DE_ratio	Overall LA_ratio
	(1)	(2)	(3)	(4)
Avg_temperature $_{it-1}$	-0.0271***	-0.0328***	-0.0283***	-0.0214**
	(-2.4)	(-2.64)	(-2.75)	(-2.33)
DE_ratio $_{it-1}$	-0.0003	-0.0009	-0.0009	-0.0002
	(-0.64)	(-0.9)	(-0.68)	(-0.78)
Avg_temperature $_{it-1}$×DE_ratio $_{it-1}$			-0.0108***	
			(-2.54)	
Avg_temperature $_{it-1}$×LA_ratio $_{it-1}$				-0.0150***
				(-2.59)
ROA $_{it-1}$	1.2282	0.9016	1.0833	1.0645
	(1.23)	(0.8)	(1.25)	(1.23)
cash_reserve $_{it-1}$	-0.2705	-0.1657	-0.3536	-0.2826
	(-1.01)	(-0.45)	(-0.06)	(-0.05)
Size $_{it-1}$	0.0854	0.0603	0.0684	0.0665
	(0.74)	(0.47)	(0.52)	(0.51)
Q_ratio $_{it-1}$	0.0360	0.0808***	0.0052	0.0050
	(1.38)	(2.44)	(0.58)	(0.56)
LA_ratio $_{it-1}$	-0.1769	-0.0948	-0.1768***	-0.2611*
	(-1.31)	(-0.43)	(-4.28)	(-1.75)
Current_Ratio $_{it-1}$	0.0346***	0.0394	0.0216***	0.0215***
	(3.25)	(1.01)	(3.10)	(3.08)
STI$_{it-1}$			-0.0215	-0.0213
			(-0.21)	(-0.19)
Adj. R^2	0.4266	0.5795	0.2111	0.2871
Firm-Fixed Effects	Yes	Yes	Yes	Yes
Year-Quarter Fixed Effects	Yes	Yes	Yes	Yes
Observations	2003	2411	7384	7384

Table 7 shows the impact of the high average temperature on the natural logarithm of newly issued debt when the LA_ratio is above the 50th percentile of the overall distribution of a firm (Column 1), and when the DE_ratio is above the 50th percentile of the overall distribution of a firm (Column 2). Columns 3 and 4 show the interaction between Avg_temperature and DE_ratio and LA_ratio, respectively. The dependent variable is the natural logarithm of newly issued debt maturity (*Log(Maturity)*) and independent variables are the return on assets (ROA), debt-to-equity ratio as leverage measure, cash holdings, Tobin's Q ratio, short-term investment ratio (STI), and the size of the firm (natural logarithm of total assets). To improve interpretability, the average temperature is scaled by dividing by 10. As a result, the coefficient represents the effect of a 10°F increase in temperature on Log(Maturity). The standard errors have been clustered at the firm level and fitted for heteroskedasticity. The coefficients of estimations are presented with ***, **, and * which show statistical significance at 1%, 5%, and 10% levels. The t-values are reported in parentheses. The t-statistics are adjusted for both heteroskedasticity and within correlations.

Table 8: Matching analysis based on high and low-temperature risks for the natural logarithm of new debt issue maturity.

Panel A

Matching variables: industry, size, and current ratio

Log(Maturity)	N	Mean	Std Dev	Std Err	t Value	Pr > |t|
0: Control group	1940	2.3176	0.5151	0.0117		
1: Treatment group	1940	2.2688	0.5128	0.0116		
Diff (1-2): pooled		0.0489	0.514	0.0165	2.96	0.0031
Diff (1-2): Satterthwaite		0.0489		0.0165	2.96	0.0031

Equality of Variances

Method: Folded F	*F Value*: 1.01	*Pr > F:* 0.8474

Panel B

Matching variables: industry, size, and ROA

Log(Maturity)	N	Mean	Std Dev	Std Err	t Value	Pr > |t|
0: Control group	1988	2.3195	0.5175	0.0116		
1: Treatment group	1988	2.2698	0.5143	0.0115		
Diff (1-2): pooled		0.0497	0.5159	0.0164	3.04	0.0024
Diff (1-2): Satterthwaite		0.0497		0.0164	3.04	0.0024

Equality of Variances

Method: Folded F	*F Value:* 1.012	*Pr > F:* 786

Table 8 presents matching analyses that compare the Log(maturity) of firms with high and low levels of temperature risk based on firm characteristics such as firm size, current ratio, industry in Panel A, firm size, industry, and ROA as matching variables in Panel B. The test then compares the maturity of new debt issues of firms in the same year by matching high and low-temperature-risk firms to analyze whether they are significantly different. The low-temperature risk group is identified as "0" and the high-temperature risk group is identified as "1". The t-value shows whether the two groups are significantly different or not. The equality of variance test shows whether the variance between two groups is equal or not. To be econometrically sound, the variance between both groups should be constant.

Table 9: Effect of high-temperature risks on *Log(Maturity)* for firms with varying credit ratings.

Variables	**S&P Quality Ranking**	**Poor Credit Ratings**	**Good Credit Ratings**
	(1)	**(2)**	**(3)**
Avg_temperature $_{it-1}$	-0.0191***	-0.2333**	0.0323**
	(-2.69)	(-2.18)	(2.04)
Avg_temperature $_{it-1}$ **× S&PQualityRank** $_{it-1}$	0.0151*		
	(1.68)		
S&PQualityRank $_{it-1}$	0.0722**		
	(2.27)		
LTissuanceRank $_{it-1}$		0.0520**	0.0532***
		(2.26)	(2.72)
Controls	Yes	Yes	Yes
Adj. R^2	0.0953	0.1022	0.446
Firm-Fixed Effects	Yes	Yes	Yes
Year-Quarter Fixed Effects	Yes	Yes	Yes
Observations	940	278	662

Table 9 shows the impact of the high average temperature on the natural logarithm of newly issued debt when the credit ratings interacted with temperature risk (Column 1), good credit rating subsample (Column 2), and poor credit rating subsample (Column 3). The dependent variable is the natural logarithm of newly issued debt maturity (*Log(Maturity)*) and independent variables are the return on assets (ROA), debt-to-equity ratio as leverage measure, cash holdings, Tobin's Q ratio, standalone credit ratings, and the size of the firm (natural logarithm of total assets). To improve interpretability, the average temperature is scaled by dividing by 10. As a result, the coefficient represents the effect of a 10°F increase in temperature on Log(Maturity). The standard errors have been clustered at the firm level and fitted for heteroskedasticity. The coefficients of estimations are presented with ***, **, and * which show statistical significance at 1%, 5%, and 10% levels. The t-values are reported in parentheses. The t-statistics are adjusted for both heteroskedasticity and within correlations.

Table 10: Panel A: Placebo test- Impact of high temperature on newly issued debt maturity. Panel B: Difference-in-Differences estimation- Effect of high-temperature risk and hurricane in Florida on new debt issue maturity. Panel C: Untransformed maturity and temperature risks.

Panel A		Panel B	
Variable	**Log(Maturity)**	**Variables**	**Log(Maturity)**
	(1)		**(1)**
		HighTempRisk $_{it-1}$	-0.0921**
AvgTemperaturePlacebo$_{it-1}$	-0.0021		(-2.17)
	(-0.26)	**HighTempRisk** $_{it-1}$**× HurricaneYears**$_{t-1}$	-0.1639**
			(-2.27)
Controls	Yes	**Controls**	Yes
R^2	0.2403	**R^2**	0.2193
Year-Quarter FE	Yes	**Year-Quarter FE**	Yes
Firm FE	Yes	**Firm FE**	Yes
Observations	7384	**Observations**	607

Panel C		
Variables	**Maturity**	**Maturity**
	(1)	**(2)**
Avg_temperature$_{it-1}$	-0.00152**	
	(-2.33)	
Temperature_volatility$_{it-1}$		-0.00081***
		(-2.52)
Controls	Yes	Yes
R^2	0.0483	0.0465
Year-Quarter FE	Yes	Yes
Firm FE	Yes	Yes
Observations	7384	7384

Panel A Column 1 of Table 10 shows the results of panel regression on the maturity of newly issued debt. The dependent variable is the natural logarithm of newly issued debt maturity (Log(Maturity*)*) and the independent variables are Avg_temperature_placebo which is generated by assigning arbitrary numbers (ranging from 30 to 110, and then divided by 10), the return on assets (ROA), asset-liability ratio (AL ratio), debt-to-equity ratio as leverage measure, the logarithm of cash holdings (cash_l), Tobin's Q ratio, and the size of the firm (natural logarithm of total assets). To improve interpretability, the average temperature is scaled by dividing by 10. As a result, the coefficient represents the effect of a 10°F increase in temperature on Log(Maturity). The standard errors have been clustered at the firm level and fitted for heteroskedasticity. Panel B of Table 10 shows the effect of the impact of the Atlantic hurricane season and immediate disasters on Log(Maturity) for firms situated in the state of Florida, using a DiD estimation method. As fixed effects (firm and year-quarter) are employed, HurricaneYears is not present as a standalone variable in the model. Panel C shows the regression results using the untransformed weighted average maturity as the dependent variable against persistent temperature risk and short-term temperature fluctuations. Different control variables are also added. The coefficients of estimations are presented with ***, **, and * which show statistical significance at 1%, 5%, and 10% levels. The t-statistics are reported in parentheses.

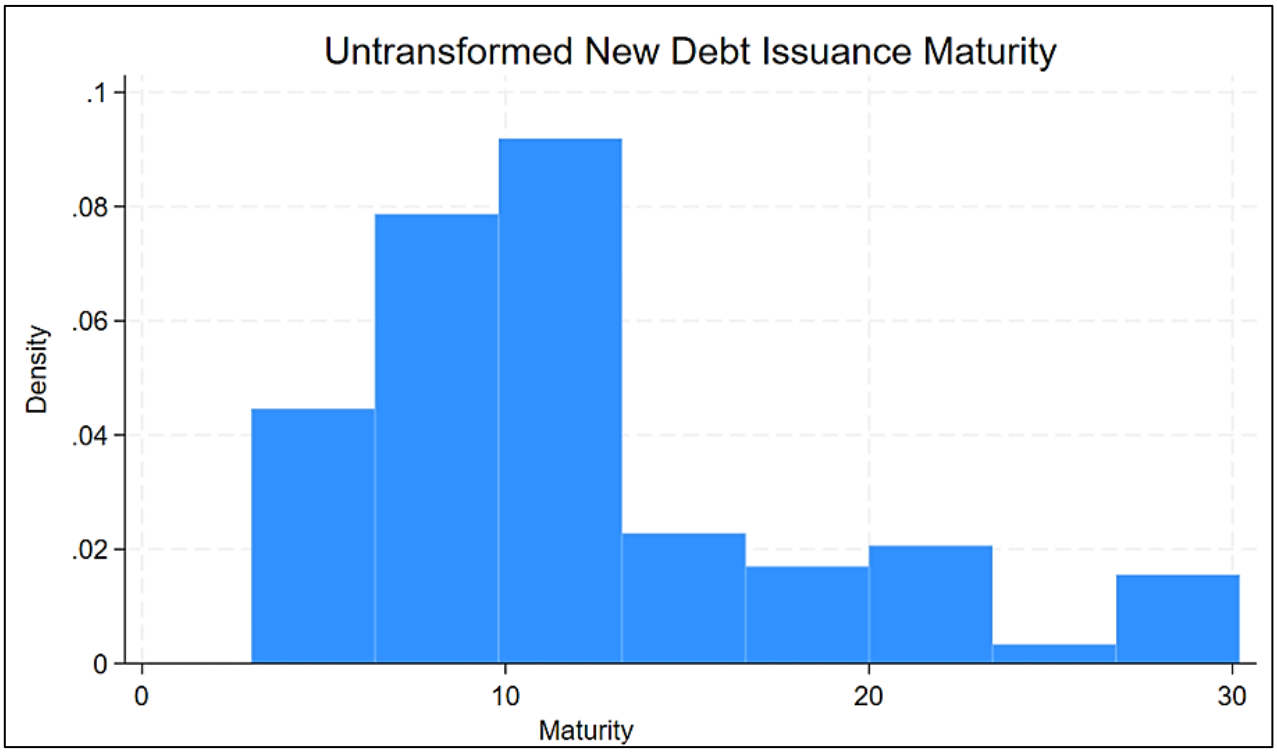


Figure 1: Distribution of untransformed weighted average new debt issuance maturity.

Figure 1 presents the histogram of the weighted average untransformed maturity of new debt issuances. The distribution is right-skewed, which justifies the use of the natural logarithm of new debt issuances as the main dependent variable, as supported by Brockman et al. (2010) and Huang et al. (2023). Applying a natural logarithm to a right-skewed variable helps to reduce skewness and make the data more normally distributed. This transformation minimizes the impact of extreme values, stabilizes variance, and enhances linear relationships between variables. This also facilitates easier interpretation and analysis. Overall, using the natural logarithm improves the suitability of skewed data for statistical modeling and analysis.