ERASMUS UNIVERSITY ROTTERDAM
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DOUBLE TROUBLE ON THE MUNICIPAL BOND MARKET

A cross-sectional analysis of the relationship between adaptive capacity and annualized issuance costs for counties that are physically exposed to climate hazards.

Abstract
This study investigates whether adaptive capacity is recognized as a determinant of physical risk on the municipal bond market. Using a sample of municipal bonds issued by 39 coastal counties exposed to rising sea levels, I find that counties with a low adaptive capacity face additional issuance costs for issuing municipal bonds with a maturity beyond 2035. The relationship is economically significant, as a one standard deviation decrease in adaptive capacity results in an increase of total annual issuance costs of 7,106,343.63 US Dollar for the average county. The negative relationship between adaptive capacity and bond issuance costs is driven by the mitigating influence of adaptive capacity, as the relationship is not significant for a sample of municipal bonds issued by counties without explicit physical exposure to climate hazards.

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1. INTRODUCTION

The predicted rise in global temperatures and the transition towards a low-carbon economy create a complex set of climate change risks for the financial system (Batten, Sowerbutt and Tanaka, 2016). For simplicity, climate change risks are frequently divided into physical risks and transition risks (Bolton, Despres, Pereira da Silva, Samana, and Svartzman, 2020). Physical risks are defined as "*risks that arise from the interaction of climate-related hazards, including hazardous events and trends, with the vulnerability of exposure to human and natural systems, including their ability to adapt*" (Batten et al., 2016). They represent the economic costs caused by an increasing number of acute climate hazards, such as storms and heat waves, and by chronic climate hazards, such as rising sea levels (Bolton et al., 2020). Transition risks are defined as "*the risks of economic dislocation and financial losses associated with the transition to a lower-carbon economy*" (Batten et al., 2016). They represent the risks associated with changing policy measures, technological breakthroughs, and changing market preferences (Bolton et al., 2020).

Due to their scale and complex interactions, climate change risks can be seen as a potential source of systemic risk in the financial system (Litterman et al., 2020). Adrian, Covitz and Liang (2014) define systemic risk as "*the potential for widespread financial externalities, whether from corrections in asset valuations, asset fire sales, or other forms of contagion, to amplify financial shocks and in extreme cases disrupt financial intermediation*". The potential for widespread financial externalities is the highest when the prices of various classes of assets do not reflect climate change risks, as this implies that market participants are unaware of the future economic condition of an asset (Litterman et al., 2020). Acute or chronic climate hazards could abruptly inform them on the true economic condition of the asset and could lead to a sudden repricing (Federal Reserve, 2021). Such a sudden repricing could cascade into significant losses for leveraged financial intermediaries and could eventually disrupt the financial system (Litterman et al., 2020).

In a world with perfect information on climate hazards and assets' exposure to them, asset prices would already reflect climate change risks (Federal Reserve, 2021). However, climate change risks are driven by uncertainty on the precise timing and magnitude of climate hazards (Pachauri et al., 2014). Furthermore, market participants have minimal information on the exposure of financial assets to climate hazards (Federal Reserve, 2021). Both these factors reduce the probability that climate change risks are efficiently priced *ex ante*. Consequently, central banks and other financial regulators are questioning whether an expansion of disclosure laws is necessary to maintain financial stability (Litterman et al., 2020).

The necessity of an expansion of disclosure laws depends on the current ability of market participants to correctly recognize and price climate change risks. The regulatory relevance of this question has attracted the interest of various academic scholars, who empirically analyse the pricing of climate change risks (Hong, Li, and Xu, 2019). While there are substantial differences between these studies, there are also substantial similarities. An example of such a similarity is the focus on physical exposure as the single determinant of physical risk in the studies by Bernstein, Gustafson, and Lewis (2019), Murfin and Spiegel (2019), Goldsmith-Pinkham, Gustafson, Lewis, and Schwert (2021), and Painter (2020). In addition to physical exposure, adaptive capacity also determines the physical risk of a socioeconomic system or asset (Smit and Pilofosova, 2003). The adaptive capacity of a socioeconomic system represents its resources available for adaptation, as well as its ability to use these resources effectively in the pursuit of adaptation. In practical terms, adaptive capacity reflects a socioeconomic system's ability to design and implement effective adaptation measures (Brooks and Adger, 2005).

Substantial physical exposure to climate hazards can correspond to little physical risk if a socioeconomic system has a high adaptive capacity. In Amsterdam for example, 83 billion US Dollar is exposed to inundation risk, but annual flood losses do not exceed 3 million US Dollar. In contrast, Ho Chi Minh City has 104 million US Dollar in annual flood losses while having one fifth of Amsterdam's exposure (Hallegatte, Green, Nicholls, and Corfee-Morlot, 2013). To my knowledge, previous studies focused on the pricing of physical risk on financial markets have not recognized adaptive capacity as a determinant of physical risk. Additional research is therefore necessary to understand whether market participants are aware of the mitigating influence of adaptive capacity on physical risk. To contribute to current academic literature, this study focusses on the following research question:

Is adaptive capacity recognized as a determinant of physical risk on the municipal bond market?

The research question is answered using a cross-sectional regression analysis using a recent sample of municipal bonds issued by American counties. The inherently regional scale of the municipal bond market makes it the most straightforward financial market to study the pricing of regional differences, such as adaptive capacity. The municipal bond data is obtained through the Bloomberg database and the adaptive capacity data is obtained through the Urban Adaptation Assessment database of the University of Notre Dame.

This study contributes to two streams of academic literature. First, this study adds to the literature focused on the pricing of climate change risks. Atanasova and Schwarz (2019) and Bolton and Kacperczyk (2019) find that transition risk is priced on the stock market. Hong et al. (2019) find that drought risk is not recognized by market participants on the stock market. Bernstein et al. (2019) conclude that inundation risk caused by rising sea levels is priced on the real estate market, but Murfin and Spiegel (2019) provide contradicting evidence. Painter (2020) and Goldsmith-Pinkham et al. (2019) also focus on inundation risk caused by rising sea levels and find this risk to be priced on the municipal bond market. The second stream of academic literature to which this study contributes is focused on the determinants of municipal bond issuance costs. Previously discovered determinants of issuance costs include credit rating (Cornaggia, Cornaggia, and Israelsen, 2017), market transparency (Schultz, 2012), local government policy (Gao, Lee, and Murphy, 2019), and physical exposure to rising sea levels (Painter, 2020).

The results of this study are of importance to municipal governments. As much as 90 percent of municipal capital spending in the United States is financed through municipal bonds (Marlowe, 2015). Additional issuance costs on the municipal bond market can therefore quickly amount to a significant additional expenditure. Painter (2020) shows that physical exposure increases bond issuance costs for municipalities. He describes this as an inconvenient truth, as physically exposed municipalities are already expected to face substantial fiscal stress due to climate change. The results of this study could show an even more inconvenient truth. If bond issuance costs for physically exposed counties are negatively related to their adaptive capacity, then the highest bond issuance costs are faced by the counties that are already the least able to deal with their physical exposure. I refer to this scenario as double trouble on the municipal bond market.

The results of this study are also of importance to financial regulators. Congress and the Securities Exchange Commission oversee the municipal bond market and recently asked market participants whether additional disclosure of climate change risks is necessary (Litterman et al., 2020). Painter (2020) and Goldsmith-Pinkham et al. (2021) show that physical exposure is recognized as a determinant of physical risk on the municipal bond market. This study assesses whether the other determinant of physical risk, adaptive capacity, is also recognized on the municipal bond market. If both determinants of physical risk are recognized and priced, an extension of disclosure laws may be unnecessary.

The remainder of this paper is structured as follows. In the second section, the academic literature focused on the pricing of climate change risks is discussed. In the third section, the data and methodology are presented. The empirical results of the cross-sectional regression analysis are described in the fourth section. In the final section, a conclusion is drawn and suggestions for future research are presented.

2. LITERATURE REVIEW

The ability of financial markets to efficiently process information has drawn academic interest for several decades. In recent years, this academic field is extended with research focused on the ability of financial markets to efficiently process information related to climate change risks (Hong et al., 2019). These studies are divided into three categories based on the financial market of consideration. Section 2.1 discusses three empirical studies focused on the pricing of climate change risk on the stock market. Section 2.2 discusses the empirical results of two studies focused on the pricing of climate change risk on the commercial and residential real estate market. The empirical studies discussed in section 2.3 are the most closely related to this study and focus on the pricing of climate change risks on the municipal bond market.

2.1 The pricing of climate change risk on the stock market

One of the sectors most affected by climate change risks is the fossil fuel sector. In 2015, 195 countries signed the Paris Agreement to set a collective goal of limiting global warming to 2 degrees Celsius (Batten et al., 2016). To have at least 50 percent chance on achieving this collective goal, the cumulative carbon emissions between 2011 and 2050 should not exceed 1,100 gigatons of carbon dioxide. However, the carbon dioxide emissions contained in current fossil fuel reserves contain approximately three times the defined threshold (McGlade and Elkins, 2015). This implies that, in time, these fossil fuel reserves will lose their value and become '*stranded assets*' (Bolton et al., 2020).

The Carbon Tracker Initiative (2011) was the first to explicitly recognize that fossil fuel reserves becoming unburnable should be followed by a significant reduction in the market value of fossil fuel companies, as half their market value is represented by their fossil fuel reserves. Atanasova and Schwarz (2019) assess whether the transition risk faced by the fossil fuel sector is priced on the stock market. They use a sample of 600 North American oil companies and analyse the relationship between market value and proven reserves for the period from 1999 to 2018. They document a negative relationship between the market value of oil companies and the growth of oil reserves, which is entirely driven by the growth of undeveloped reserves. Undeveloped reserves are located in new wells and require major capital expenditures for completion, while developed reserves are oil reserves located in existing wells. The strength of the discovered relationship is the strongest for oil producers with higher extraction cost and for oil producers with reserves in countries with strict climate policy. Furthermore, the strength of the relationship increases after the 2015 Paris Agreement. These results indicate that investors on the stock market understand and recognize the transition risk faced by the fossil fuel sector.

Bolton and Kacperczyk (2021) denote that the transition towards a low-carbon economy does not only create a transition risk for companies in the fossil fuel sectors. Companies in various other sectors also rely on fossil fuels for their energy use, which exposes them to two sources of transition risk. First, companies that rely on fossil fuels for their energy demand are exposed to increasing carbon prices and policy interventions aimed to limit emissions. Second, these companies are exposed to technology risk caused by decreasing prices for renewable energy. Bolton and Kacperczyk (2021) refer to this risk as carbon risk, as fossil fuel dependency is reflected by carbon emissions. They find that, for all three categories of carbon emissions, an increase in carbon emissions results in an increase in stock returns. The effect is both statistically and economically significant, as a one standard deviation increase in emissions results in a 1.8 to 4.0 percent increase in annual stock returns. The relationship between carbon dioxide emissions and stock returns has only recently become significant, which indicates that investor awareness with respect to climate change risks has increased. The results of Bolton and Kacperczyk (2021) show that not only the transition risk in the fossil fuel sectors is priced on the stock market, but also the transition risk in various other sectors.

The pricing of physical risk on the stock market received less academic interest than the pricing of transition risk. One of the sectors most affected sectors by physical risk is the food and agriculture sector (Litterman et al., 2020). Hong, Li, and Xu (2019) assess whether the stock prices of food companies reflect their exposure to drought risks. Of all extreme weather events that are expected to be amplified by climate change, droughts are the most disrupting to food production. The cross-sectional dispersion in drought risk across the world is magnified by climate change, with some countries being adversely affected while others are benefitting. The food industry in most countries is made up of small to medium sized companies that carry a substantial exposure to local climate conditions. This implies that food companies in countries negatively affected by drought trends can be expected to face disappointing crop yields in the future, which will cascade into disappointing financial performance. If the drought risk is efficiently priced on the stock market, the publicly available information on drought trends should not be usable in forecasting stock returns. However, Hong et al. (2019) find that drought trends can be used to forecast the stock returns of food companies. The difference in stock return between positively and negatively affected food companies is 7 percent annually. These results show that drought risk faced by the food sector is not recognize on the stock market.

2.2 The pricing of climate change risk on the real estate market

The Federal Reserve (2021) argues that climate change risk on the commercial and residential real estate market poses a particular threat to financial stability, as a sudden revaluation on the real estate market can cascade into the bankruptcy of financial intermediaries through the mortgage lending market. The pricing of climate change on the real estate market is not only important from the perspective of the financial stability, but also from the perspective of millions of households across the United States. This is a consequence of the fact that real estate is the most important asset for the average American household, with 40 percent of household wealth allocated to real estate (Board of Governance of Federal Reserve System, 2013).

The commercial and residential real estate market is exposed to both transition risk and physical risk. So far, the pricing of physical risk received the most attention of academic scholars. Most of these studies focus on the physical risk created by rising sea levels, which is arguably one of the most salient climate change risks. If carbon dioxide emissions continue unabated, sea levels could rise as much as six feet by 2100. Such a rise in sea levels would lead to the inundation of over 2 percent of all American residential real estate, with a current market value of 882 billion US Dollar. The physical risk posed by rising sea levels is unevenly distributed and some regions and states are disproportionally affected. Hawaii and Florida, for example, risk losing over 10 percent of their current residential real estate (Rao, 2017).

Bernstein et al. (2019) assess the pricing of inundation risk on the real estate market by combining real estate transaction data with sea level rise exposure data on a property level. They show that exposed residential properties sell at a 7 percent discount compared to unexposed residential properties with similar characteristics. A residential property is defined as exposed if sea levels rising by six feet would lead to severe inundation. The results are driven by non-owner occupiers, who are more sophisticated and purchase real estate for investment purposes. Exposed non-owner-occupied properties trade at an average discount of 10 percent, while exposed owner occupied properties trade at a similar price as unexposed owner-occupied real estate. Another distinction in the empirical results is based on regional climate change beliefs. While there is no discount visible for exposed owner-occupied real estate in regions with low climate change beliefs, an 8.5 percent discount is visible in regions with high climate change beliefs.

In contrast to Bernstein et al. (2019), Murfin and Spiegel (2019) do not find a significant price effect of exposure to sea level rise. They denote that both the location and elevation of a residential property play a large role in hedonic pricing models, which creates a challenge for studies focused on the pricing of sea level rise exposure since the exposure of a property is highly correlated to its elevation and location. By making use of regional variation in the magnitude of sea level rise, Murfin and Spiegel (2019) are able to disentangle the value of the inundation risk and the value of elevation and location. The regional variation in sea level rise is primarily driven by differences in land subsidence and land rebound. They find that inundation risk does not have a statistically significant effect on real estate prices. In line with Bernstein et al. (2019), they also consider the possibility of heterogenous price effects across various pockets of the market. However, they do not find statistically different results for different market pockets. The empirical results of Murfin and Spiegel (2019) indicate that market participants are either unaware of the inundation risk caused by rising sea levels, or belief that timely adaptation will prevent the inundation of their property.

The contradicting results of Bernstein et al. (2019) and Murfin and Spiegel (2019) challenge the formulation of a conclusion on the pricing of climate change risk on the real estate market. Murfin and Spiegel (2019) try to reconcile their empirical results with the empirical results of Bernstein et al. (2019). They show that household sophistication appears to be positively correlated with relative sea level rise, while regional climate change beliefs are negatively correlated with relative sea level rise. A possible rationale that aligns the results of Bernstein et al. (2019) and Murfin and Spiegel (2019) is provided by the fact that exposed households are less sophisticated and have lower climate change beliefs, while sophisticated households who do belief in climate change are relatively unexposed. The absent inundation discount in the study of Murfin and Spiegel (2019) could also be explained by a poor understanding of inundation risk by market participants, who may be unaware of the influence of land subsidence and land rebound. Additional research is necessary to further narrow down the possible interpretations of the empirical results provided by Bernstein et al. (2019) and Murfin and Spiegel (2019).

2.3 The pricing of climate change risk on the municipal bond market

The previously discussed climate change risks on the stock market and real estate market also affect municipal budgets through a complex system of sales, income, severance, and property taxes (Morris, Kaufman, and Doshi, 2019). The fiscal vulnerability of municipalities to climate change risk can be substantiated by looking at the interaction of one source of physical risk with one aspect of municipal budgets. Dahl et al. (2018) denote that sea levels rising by 6 feet would lead to the inundation of over 2.4 million residential properties, which currently generate over 12 billion US Dollar in municipal property taxes. In this scenario, 120 coastal municipalities would lose over 20 percent of their property tax base and 30 municipalities would lose over 50 percent of their property tax base. Depending on the state, property taxes represent between 10 percent and 56 percent of municipal revenues. Within states, these numbers can rise even further in coastal municipalities (U.S. Census Bureau, 2012). These estimates imply that climate change risks could already decrease municipal revenues by as much as 28 percent through a single transmission channel.

Climate change risks do not only affect municipal budgets on the revenue side, but also on the expenditure side. For municipalities exposed to rising sea levels, additional expenditures include additional adaptation costs and additional maintenance and reparation costs (Hunt and Watkiss, 2011). These additional expenditures are relatively inflexible and remain stable with declining populations (Kousky, Kunreuther, Lingle, and Shabman, 2018). The significance of these additional expenditures can be substantiated by looking at Miami, where adaptation costs are estimated at 51 billion US Dollar (Molinaroli, Guerzoni, and Suman, 2019).

The fiscal vulnerability of municipalities to climate change implies that their ability to service their debt obligations could be impaired. This could lead to numerous downgrades and defaults on the 3.8 trillion US Dollar municipal bond market (Litterman et al., 2020). By 2030, over 15 percent of municipal bonds will be issued by municipalities whose annual GDP is reduced by more than 1 percent due to climate change risk. By 2100, over 40 percent of municipal bonds will be issued by municipalities whose annual GDP is reduced by more than 3 percent (Blackrock Investment Institute, 2019). Though regulations require municipalities to disclose all fiscal risk material to the municipal bond holder, disclosure of fiscal risk caused by climate change remains minimal (Morris et al., 2019).

Both Painter (2020) and Goldsmith-Pinkham et al. (2021) assess whether the minimal disclosure of climate change risk on the municipal bond market prevents the pricing of climate change risks. Painter (2020) assesses whether exposure to rising sea levels significantly influences the issuance costs of municipal bonds. He uses expected mean annual GDP loss from sea level rise, which is provided by Hallegatte et al. (2013), to measure exposure to rising sea levels. The issuance cost of a municipal bond reflects investor demand for the bond and is made up of annualized gross spread and yield at issuance. The gross spread of a municipal bond is also known as the underwriter's discount and refers to the remuneration paid to the employed underwriters for selling the municipal bond (Joffe, 2016). A high gross spread is an indication of high search costs for the underwriters to place the bond. After the issuing municipality and the underwriters agree on a gross spread, the underwriters sell the entire municipal bond issue to the public for the lowest yield possible. If municipal bond investors recognize sea level rise as a source of fiscal risk, then underwriters would experience higher search costs and investors would require a higher yield.

Painter (2020) expects the effect to be differentiated across three dimensions. First, he expects the effect to be particularly strong for long-maturity bonds since annual flooding damage is expected to increase with rising sea levels. Second, he expects the effect to be particularly strong for lower-rated municipalities since their weaker infrastructure and smaller fiscal capacity make them particularly exposed to physical risk. Third, he expects the effect to be stronger after the issuance of an influential report on the magnitude of climate risk by Nicholas Stern in 2006. In line with his expectations, Painter (2020) finds a statistically significant relationship between climate risk and issuance costs for long-maturity bonds. The significant relationship is driven by long-maturity municipal bonds issued by lower-rated counties after 2006. For long-maturity bonds, a 1 percent increase in mean annual GDP loss from sea level rise is related to an increase in annualized issuance costs of 23.4 basis points.

Goldsmith-Pinkham et al. (2021) also examine whether exposure to rising sea levels is recognized as a source of potential fiscal stress in the municipal bond market. Their sample is made up of bonds issued by coastal school districts, since school districts are particularly dependent on property taxes for their revenue. This creates a direct transmission channel between the ability of a school district to service its debt and the anticipated effects of rising sea levels on real estate values. Using data from the National Oceanic and Atmospheric Administration, they determine the exposure to sea level rise of each property included in the school districts property tax base. About 46 percent of the municipal bonds in their sample is from school districts exposed to inundation if sea levels rise by 6 feet. For the average school district, sea levels rising by 6 feet would translate to 7 percent of total properties being inundated.

Goldsmith-Pinkham et al. (2021) assess how a school district's exposure to sea level rise relates to the credit spread of municipal bonds, which gives an indication of the additional risk experienced by bondholders. Their results show that the relationship is not statistically significant for bonds issued between 2001 and 2011. The relationship becomes statistically significant in 2012, which is in line with sea level rise projections and climate risk awareness increasing between 2001 and 2011. After 2014, the strength of the relationship increases further. The coefficients indicate that a one standard deviation increase in a school district's exposure to rising sea levels is related to a 5 basis points increase in credits spread, which amounts to 9 percent of the average spread. In line with Painter (2020), Goldsmith-Pinkham et al. (2021) also find that the relationship is only statistically significant for long-maturity bonds.

Goldsmith-Pinkham et al. (2021) translate the discovered relationship between inundation risk and credit spread into implied changes in future municipal cash flows. They find that their estimated coefficients are in line with a 2 to 5 percent reduction in the present value of municipal cash flows, or an increase of 1 to 3 percent in the volatility of the municipal cash flows. Goldsmith-Pinkham et al. (2021) also convert the estimates of Painter (2020) into implied changes in future municipal cash flows. They find that Painter's (2020) increase in annualized issuance cost is in line with a 20 percent reduction in the present value of future municipal cash flows. This implied reduction in future cash flows substantially exceeds the revenue loss implied by Painter's (2020) dependent variable.

The results of Painter (2020) and Goldsmith-Pinkham et al. (2021) do not only differ in the magnitude of the effect, but also in the timing of the effect. Goldsmith-Pinkham et al. (2021) find that municipal bond investors start pricing physical risk in 2012, while Painter (2020) finds a significant relationship from 2007 onwards. Goldsmith-Pinkham et al. (2021) try to reconcile their findings with the results of Painter (2020) and replicate the analysis of Painter (2020). In contrast to Painter (2020), they do provide year-by-year estimates and show that the estimates of Painter

(2020) are the largest in 2009. Subsequently, the magnitude and statistical significance of the effect decrease. The decreasing magnitude and significance are hard to reconcile with increasing sea level rise projections and climate risk awareness and could indicate that the results found by Painter (2020) are spurious.

2.4 Measurement of physical risk in academic literature

The academic literature focused on the pricing of physical risk on financial markets is characterized by similarities across various dimensions. Bernstein et al. (2019), Murfin and Spiegel (2019), Goldsmith-Pinkham et al. (2021), and Painter (2020) all focus on sea level rise as their source of physical risk. Bernstein et al. (2019), Murfin and Spiegel (2019), and Goldsmith-Pinkham et al. (2021) specifically focus on the physical risk rising sea levels pose to coastal real estate. Bernstein et al. (2019) and Goldsmith-Pinkham et al. (2021) base their inundation risk measure on the SLR viewer of the National Oceanic and Atmospheric Administration, which provides inundation risk on a property level. Murfin and Spiegel (2019) use a similar methodology, but also incorporate land rebound and land subsidence in their measure of inundation risk. Painter (2020) looks beyond coastal real estate and considers expected mean annual GDP loss as his measure of physical risk. This measure comes from Hallegatte et al. (2013), who provide 108 different scenarios of future flood losses in the 136 largest coastal cities.

A second similarity between the academic articles focused on the pricing of physical risk on financial markets is that their physical risk measures are based on a uniformly distributed implementation of adaptation measures. Bernstein et al. (2019), Murfin and Spiegel (2019), and Goldsmith-Pinkham et al. (2021) all consider physical risk in a scenario without further implementation of adaptation measures. This is a consequence of their usage of the National Oceanic and Atmospheric Administration SLR viewer, which does not account for future changes in coastal defences (National Oceanic and Atmospheric Administration, 2017). Conversely, the physical risk measure of Painter (2020) comes from a scenario in which all coastal cities are able to maintain present flood probabilities through extensive adaptation measures. The usage of a specific scenario as a prediction of future flood losses goes against the intention of Hallegatte et al. (2013), who explicitly state that their future flood loss scenarios should not be considered as a point estimates of future flood losses.

By basing their physical risk estimates on a scenario with uniformly distributed implementation of adaptation measures, Bernstein et al. (2019), Murfin and Spiegel (2019), Goldsmith-Pinkham et al. (2021), and Painter (2020) leave adaptive capacity out of consideration. Hence, it remains empirically unknown whether adaptive capacity is recognized as a determinant of physical risk on financial markets. The influence of adaptive capacity on the magnitude of physical risk is significant (Smit and Pilofosova, 2003). For the physical risk measure used by Bernstein et al. (2019), Murfin and Spiegel (2019), Goldsmith-Pinkham et al. (2021), a high adaptive capacity can reduce the risk by as much as 88 percent (The Technical Report for the Fourth National Climate Assessment, 2017). For the physical risk measure used by Painter (2020), a high adaptive capacity can reduce the risk by much as 95 percent (Hallegatte et al., 2013).

This study empirically analyses whether adaptive capacity is recognized as a determinant of physical risk on the municipal bond market. If investors on the municipal bond market recognize the mitigating influence of adaptive capacity on physical risk, then adaptive capacity should be negatively related to the issuance costs of municipal bonds. Note that this negative relationship should only be present for counties with substantial physical exposure, as the mitigating influence of adaptive capacity on physical risk is only present for municipalities with significant physical exposure. Based on this rationale, the following null hypothesis and alternative hypothesis are formulated:

H_0: A higher level of adaptive capacity does not result in lower municipal bond issuance costs for counties with substantial physical exposure to climate hazards.

H_a: A higher level of adaptive capacity does result in lower municipal bond issuance costs for counties with substantial physical exposure to climate hazards.

3. DATA AND METHODOLOGY

3.1 Data

This study focusses on the pricing of physical risk on the municipal bond market. More specifically, this study focusses on the ability of investors to recognize the influence of adaptive capacity on the physical risk of physically exposed counties. A sample of 22 physically exposed American coastal cities is obtained through the study of Hallegatte et al. (2013). Hallegatte et al. (2013) denote that their estimations should not be considered as point estimates of future flood losses. Instead, their estimates should be interpreted as a bandwidth of possible flood losses. In line with their recommendation, I interpret their estimations as a bandwidth of future flood losses. This bandwidth acts as evidence for the physical exposure of the 22 American cities. For these 22 cities, I obtain data on adaptive capacity through the Urban Adaptation Assessment database of the University of Notre Dame. As municipal bonds are issued at the county level, I match the 22 cities with their associated 38 counties. This means that I have 22 separate scores on adaptive capacity for a total of 38 counties.

The score used to measure adaptive capacity is not referred to as adaptive capacity in the Urban Adaptation Assessment database. They refer to the score as a readiness score, which is defined as "*the capacity of an urban society to mobilize adaptation investments from private sectors, and to target investments more effectively*". This aligns almost perfectly with the discussed description of adaptive capacity by Brooks and Adger (2005). I argue that this similarity makes the readiness scores of the Urban Adaptation Assessment database suited to measure the adaptive capacity of a city. The sample of cities, their associated counties, and their adaptive capacity scores are presented in Table 1 in the appendix.

The readiness scores included in the Urban Adaptation Assessment database are a function of economic readiness, governance readiness, and social readiness. In turn, these readiness factors are determined by various underlying variables. The following discussion of the underlying variables paraphrases some of the information from the methodological supplement to the Urban Adaptation Assessment (2018). The economic readiness of a city represents the economic conditions present to attract adaptation investment and to support the implementation of adaptation. The creditworthiness and tax incentives for renewable energy of a city are used to calculate its economic readiness. The governance readiness of a city reflects whether a city enables effective use of adaptation investment. Governance readiness is a function of the total number of federal public corruption convictions, the proportion of population with education, and the proportion of adults who believe that global warming is already causing damage. The social readiness refers to the social capacity of a city to fully profit from the positive consequence of adaptation measures. Civic engagement and general innovation capabilities are used to estimate social readiness. Further substantiation for the suitability of these variables to measure the readiness of a city is included in the methodological supplement to the Urban Adaptation Assessment (2018). For clarity, readiness is referred to as adaptive capacity in the rest of this paper.

The sample of municipal bonds used in this study is obtained through Bloomberg. The selected municipal bonds are restricted to bonds issued by the 38 counties of interest between 2015 and 2019. I only include municipal bonds with a maximum maturity beyond 2035, because Painter (2020) and Goldsmith-Pinkham et al. (2021) show that the pricing of climate change risks is restricted to long-maturity bonds. Though it is interesting to look at a difference in effect between long-maturity bonds and short-maturity bonds, I pre-emptively exclude short-maturity bonds from my sample. This decision is driven by the limited availability of municipal bond data, which is a consequence of the limited number of Bloomberg licenses held by the Erasmus University. I further restrict my sample by excluding bond with an issue size below 1 million US Dollar, bonds without a rating by Standard and Poor's, bonds without data on their gross spread, and bonds without data on their initial yield. The final sample contains 9.172 municipal bonds.

3.2 Mathematical model specification

This study assesses whether adaptive capacity is recognized as a determinant of physical risk on the municipal bond market. The following pooled OLS model is used to answer this question:

$$Annualized\ issuance\ cost_{i,j,t} = \alpha + \beta_1 * Adaptive\ Capacity_j + \beta_2 * X_{i,j,t} + \beta_{3j} * County_j + \beta_{4t} * Year_t + \varepsilon_{i,j,t}$$

The annualized issuance cost is measured as a percentage of the total amount issued and is calculated by taking the sum of the yield at issuance and the geometric average of the gross spread. The independent variable of interest is the adaptive capacity of county *j*, which is measured as a score between 0 and 1. The vector $X_{i,j,t}$ includes a total of 6 commonly used municipal bond control variables. The first control variable is the amount issued, which is measured in millions of US Dollars. The second control variable included is the maximum maturity measured in years. The third control variable is the initial S&P credit rating of municipal bond *i*, which is converted into numeric form and can take values from 1 to 22. The fourth and fifth bond control variables are both binary variables. The value of the fourth variable is 1 if municipal bond *i* is insured, and 0 otherwise. The value of the fifth control variable is 1 if the municipal bond is competitively issued and 0 if the municipal bond issue was negotiated. The final two bond control variable included are both categorical variables. The first categorical variable reflects the tax provision of the municipal bond, and the second categorical variable reflects the municipal bond type. The regression model also includes county-year fixed effects.

3.3 Descriptive statistics

Table 2 presents the descriptive statistics for the municipal bond data. The average annualized issuance cost of a municipal bond is 3.062 percent, which is made up by 0.027 percent annualized gross spread and 3.035 percent yield at issuance. A municipal bond is, on average, issued by a county with an adaptive capacity of 0.496. The average issue size of a municipal bond is 19.962 million US Dollar, and the average maximum maturity is 22.05 years. A municipal bond has an average rating of 3.429, which aligns with an AA credit rating by Standard and Poor's. The sample is for 14.5 percent made up of insured bonds, which implies that the remaining 85.6 percent is uninsured. Furthermore, 27.8 percent of the municipal bonds are competitively issued and 82.2 percent is issued through negotiation. The average issue contains 9.539 separate municipal bonds, and the average underwriter leads 608.924 municipal bond issues.

Table 2 shows that the distribution of the annualized issuance is characterized by substantial kurtosis and skewness. The observed kurtosis and skewness are driven by the outlier of 104.498, which is a consequence of an extremely high value included in the yield at issuance. Outliers can contain relevant information on the true relationship between two variables and should therefore not directly be considered as a stray (Tukey, 1960). However, outliers can have a significant influence on the relationship between two variables. This influence will be considered in the empirical results section.

Table 2 *Detailed descriptive statistics for the variables included in the pooled OLS model. The municipal bond data is obtained through Bloomberg. The sample includes 9,172 observations of bonds that are issued between 2015 and 2019 and have an issue size above 1 million US Dollar. Municipal bonds are excluded from the sample if they lack data on their gross spread, yield at issuance, and S&P credit rating. The data on the adaptive capacity of the county of issuance is obtained through the Adaptation Assessment Database of the University of Notre Dame.*

Variable	Mean	Median	St. Dev.	Min.	Max.	Skewness	Kurtosis
Annualized Issuance Cost (%)	3.062	3.098	1.269	1.403	104.498	55.728	4456.907
Annualized Gross Spread (%)	0.027	0.021	0.026	0.005	0.441	4.027	32.097
Yield at Issuance (%)	3.035	3.070	1.267	1.390	104.478	55.963	4481.913
Adaptive Capacity	0.496	0.532	0.176	0.219	0.799	(0.266)	2.082
Amount Issued (M$)	19.962	7.36	37.527	1.025	650	5.725	54.35
Maturity	22.05	20	4.86	15	42	0.931	0.63
Rating	3.429	3	2.097	1	16	1.258	4.867
Insured	0.145	0	0.352	0	1	2.020	5.081
Method	0.278	0	0.448	0	1	0.99	1.981
CUSIPS per Issue	9.539	8	7.359	1	43	1.816	6.911
Number of Leads	608.924	593	390.524	9	1334	0.579	2.427

Table 3 presents the correlation coefficients of the dependent and independent variables included in the regression model. The correlation coefficient of the annualized issuance cost and adaptive capacity is marginally negative. The apparent negative relationship is not in line with the null hypothesis of this study. Another important correlation coefficient to consider is the coefficient of adaptive capacity and bond rating, which is positive but weak. This is important to note, because a county's creditworthiness is used as an underlying variable to measure its adaptive capacity. A strong correlation coefficient would give rise to the possibility that adaptive capacity acts as a proxy for bond rating. In this case, the previously discussed issue does not appear to be a concern. The correlation coefficients between the independent variables are all relatively weak. Gujarati (1995) describes that multicollinearity poses a threat to the reliability of a regression model if a correlation coefficient between independent variables exceeds an absolute value of 0.8. In this case, none of the correlation coefficients come close to this threshold and multicollinearity does not pose a threat.

Table 3 *Correlation coefficients of the winsorized dependent variable and the independent variables. The categorical variables for municipal bond type, tax provision and year of issuance are excluded from the table. The municipal bond data is obtained through Bloomberg. The sample includes 9,172 observations of bonds that are issued between 2015 and 2019 and have an issue size above 1 million US Dollar. Municipal bonds are excluded from the sample if they lack data on their gross spread, yield at issuance, and S&P credit rating. The data on the adaptive capacity of the county of issuance is obtained through the Adaptation Assessment Database of the University of Notre Dame.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Issuance Cost	1								
2. Adaptive Capacity	-0.001	1							
3. Log(Amount)	0.018	0.032	1						
4. Maturity	0.180	0.012	0.320	1					
5. Rating	0.169	-0.057	0.006	0.114	1				
6. Insured	0.071	-0.074	-0.137	0.030	0.275	1			
7. Method	0.010	0.063	-0.140	0.020	-0.074	0.145	1		
8. Number of CUSIP	-0.152	-0.042	-0.029	-0.039	-0.134	-0.020	0.146	1	
9. Number of Leads	-0.022	0.106	0.083	0.026	-0.068	0.159	0.094	0.033	1

4. EMPIRICAL RESULTS

4.1 Main results

The regression model used in this study is employed to empirically assess whether the null hypothesis can be rejected. The null hypothesis states that a higher level of adaptive capacity does not result in lower municipal bond issuance costs for counties with substantial physical exposure to climate hazards. The parameter estimates, White standard errors, and level of significance for the pooled OLS model are presented in Table 4.

The relationship between annualized issuance cost and adaptive capacity is negative and statistically significant at a 5 percent significance level. The p-value for a one sided t-test is 0.015. On the basis of this result, the null hypothesis must be rejected. The parameter estimate presented in column 1 implies that a one standard deviation decrease (0.176) in adaptive capacity results in an increase in annualized issuance costs of 14.75 basis points. This is equivalent to an increase in average annual issuance costs of 4.82 percent, as the average annualized issuance cost of a municipal bond is 3.06 percent,. The average county issued 241 municipal bonds in the sample period and the average issue size of a municipal bond is 19.962 million US Dollar. This means that economically, a one standard deviation decrease in adaptive capacity results in an increase of total annual issuance costs of 7,106,343.63 US Dollar for the average county. Note that this is an underestimation of the true increase in annual issuance costs for a county, since my sample is restricted across various dimensions.

Table 4 *Parameter estimates of variables in the pooled OLS model. The municipal bond data is obtained through Bloomberg. The sample includes 9,172 observations of bonds that are issued between 2015 and 2019 and have an issue size above 1 million US Dollar. Municipal bonds are excluded from the sample if they lack data on their gross spread, yield at issuance, and S&P credit rating. The data on the adaptive capacity of the county of issuance is obtained through the Adaptation Assessment Database of the University of Notre Dame.*

Dependent variable:	Annualized issuance cost
Adaptive Capacity	-0.838**
	(0.386)
Amount	-0.001***
	(0.000)
Maturity	0.033***
	(0.002)
Rating	0.090***
	(0.004)
Insured	0.105***
	(0.017)
Method	0.096**
	(0.040)
Number of CUSIP	-0.008***
	(0.001)
Number of Leads	-0.000*
	(0.000)
Constant	3.388***
	(0.309)
R^2	0.189

, ** and * indicate that the underlying null hypothesis is rejected at the 10%, 5% and 1% significance level. The categorical variables for tax provision, municipal bond type, county, and year are included in the regression, but their estimates are excluded from the table for legibility.*

4.2 Robustness test

The pooled OLS model includes various bond control variables and county-year fixed effects to correctly estimate the relationship between annualized issuance costs and adaptive capacity. However, a potential concern related to the results in Table 4 comes from the outlier included in the dependent variable. As discussed, outliers can have a strong influence on a relationship between two variables. For robustness, I therefore re-estimate the pooled OLS model using a winsorized dependent variable. I choose to winsorize annualized issuance costs at a 1 percent level, as the concern is driven by one extremely high value. The parameter estimates, White standard errors, and level of significance for the pooled OLS model with a winsorized dependent variable are presented in Table 5 in the appendix.

Using the winsorized dependent variable, the relationship between annualized issuance cost and adaptive capacity remains negative and statistically significant at a 5 percent significance level.

Comparing Table 4 to Table 5, the magnitude of the coefficient decreases from -0.838 to -0.789 and the p-value for a one sided t-test increases from 0.015 to 0.018. These results show that the negative and statistically significant relationship between adaptive capacity and annualized issuance cost is not driven by the extreme value. This observation supports the argument that the null hypothesis must be rejected.

Table 5 *Parameter estimates of variables in the pooled OLS model. The independent variable is winsorized. The municipal bond data is obtained through Bloomberg. The sample includes 9,172 observations of bonds that are issued between 2015 and 2019 and have an issue size above 1 million US Dollar. Municipal bonds are excluded from the sample if they lack data on their gross spread, yield at issuance, and S&P credit rating. The data on the adaptive capacity of the county of issuance is obtained through the Adaptation Assessment Database of the University of Notre Dame.*

Dependent variable:	Annualized issuance cost
Adaptive Capacity	-0.789**
	(0.374)
Amount	-0.001***
	(0.000)
Maturity	0.030***
	(0.001)
Rating	0.084***
	(0.003)
Insured	0.109***
	(0.016)
Method	0.057***
	(0.011)
Number of CUSIP	-0.007***
	(0.001)
Number of Leads	-0.000***
	(0.000)
Constant	3.420***
	(0.302)
R^2	0.650

, ** and * indicate that the underlying null hypothesis is rejected at the 10%, 5% and 1% significance level. The categorical variables for tax provision, municipal bond type, county, and year are included in the regression, but their estimates are excluded from the table for legibility.*

4.2 Evidence on the economic mechanism

Another possible concern with respect to the discovered negative and statistically significant relationship between adaptive capacity and annualized issuance costs is that it can be explained by two different economic mechanisms. The first economic mechanism is in line with the hypothesis of this paper and implies that the negative relationship between adaptive capacity and annualized issuance costs is driven by the mitigating influence of adaptive capacity on physical risk. The second economic mechanism is not in line with the hypothesis of this paper and implies that the negative relationship between adaptive capacity and annualized issuance costs is a reflection of superior economic conditions in counties with a high adaptive capacity.

The concern that the negative relationship between adaptive capacity and annualized issuance cost is unrelated to physical risk is magnified by a study of Hastie (1972), who show that the credithworthiness and education of a county are both significantly related to a lower yield at issuance of a municipal bond. Both these variables are included in the calculation of the adaptive capacity score. However, the concern is not limited to these two underlying variables since various other underlying variables used to calculate the adaptive capacity could also be argued to reflect superior economic conditions.

A possibility to address the concern is offered by the following rationale. If the negative relationship between adaptive capacity and annualized issuance costs is truly driven by the mitigating influence of adaptive capacity on physical risk, then the relationship should not remain statistically significant for a sample of municipal bonds issued by counties without explicit physical risk. If the negative relationship is driven by superior economic conditions in counties with higher adaptive capacity, then the relationship should remain statistically significant and negative for a sample of municipal bonds issued by a county withouth explicit physical risk.

To test the economic mechanism at play, I obtain another sample of municipal bonds. Previously, I restricted the municipal bonds by only looking at bonds issued by counties associated with the coastal cities included in the paper of Hallegatte et al. (2013). This requirement can now be omitted and I therefore make use of the full set of adaptive capacity scores included in the Urban Adaptive Assessment database of the University of Notre Dame. I obtain adaptive capacity scores for 278 different American cities, which is associate with 278 different counties through data provided by the U.S. Census Bureau (2020).

Again, municipal data is obtained through Bloomberg. The sample is restricted to municipal bonds issued by the 278 counties for which I have adaptive capacity scores. A further restriction confines the sample to bonds issued in the year 2019. This restriction is driven by the limited availability of municipal bond data, caused by the few Bloomberg licenses held by the Erasmus University. The sample of municipal bonds is further restricted to bonds with a maximum maturity beyond 2035, bonds with an issue size above 1 million US Dollar, bonds with a rating by Standard and Poor's, bonds with data on their gross spread, and bonds with data on their initial yield. The final sample contains 4.092 municipal bonds.

The descriptive statistics and correlation coefficients of the second municipal bond sample are presented in table 6 and table 7, which are included in the appendix. For this sample, there is no concern related to an extreme value for the independent variable. In contrast to the first sample of municipal bonds, the correlation coefficient of annualized issuance cost and adaptive capacity is marginally positive. The apparent positive relationship is in line with the first economic mechanism. The correlation coefficient between adaptive capacity and credit rating is 0.003, which indicates that adaptive capacity does not act as a proxy for credit rating. The threat of multicollinearity remains absent, as none of the correlation coefficients come close to the discussed threshold.

The parameter estimates, White standard errors, and level of significance for the pooled OLS model are presented in table 8. The relationship between adaptive capacity and annualized issuance cost is positive and not statistically significant. The one-sided t-test yields a p-value of 0.572. The observed relationship is in line with the first of the two possible economic mechanisms, which states that the negative relationship between adaptive capacity and annualized issuance costs is driven by the mitigating influence of adaptive capacity on physical risk.

Table 8 *Parameter estimates of variables in the pooled OLS model. The independent variable is winsorized. The municipal bond data is obtained through Bloomberg. The sample includes 9,172 observations of bonds that are issued between 2015 and 2019 and have an issue size above 1 million US Dollar. Municipal bonds are excluded from the sample if they lack data on their gross spread, yield at issuance, and S&P credit rating. The data on the adaptive capacity of the county of issuance is obtained through the Adaptation Assessment Database of the University of Notre Dame.*

Dependent variable:	Annualized issuance cost
Adaptive Capacity	0.111 (0.609)
Amount	-0.001*** (0.000)
Maturity	0.036*** (0.002)
Rating	0.071*** (0.005)
Insured	0.041* (0.024)
Method	0.116*** (0.021)
Number of CUSIP	-0.003*** (0.001)
Number of Leads	0.000 (0.000)
Constant	2.129*** (0.233)
R^2	0.360

, ** and * indicate that the underlying null hypothesis is rejected at the 10%, 5% and 1% significance level. The categorical variables for tax provision, municipal bond type, and county are included in the regression, but their estimates are excluded from the table for legibility.*

5. DISCUSSION AND CONCLUSION

This paper uses the municipal bond market to study whether the mitigating role of adaptive capacity on physical risk is recognized on financial markets. The null hypothesis states that a higher level of adaptive capacity does not result in lower municipal bond issuance costs for counties with substantial physical exposure to climate hazards. The formulated null hypothesis is empirically analysed using a sample of municipal bonds issued by counties with substantial physical exposure to rising sea levels. The discussion commences with a conclusion on the hypothesis and an answer to the research question. Consequently, a limitation of this study is discussed. Finally, interesting venues for further research are defined.

The discovered relationship between adaptive capacity and annualized issuance costs is negative and statistically significant. Based on this observation, the null hypothesis is rejected. The relationship is not only statistically significant, but also economically significant. A one standard deviation decrease in adaptive capacity results in an increase of total annual issuance costs of 7,106,343.63 US Dollar for the average county. The statistically significant and negative relationship between adaptive capacity and annualized issuance costs disappears for a sample of municipal bonds issued by counties without explicit physical exposure. Altogheter, the empirical results of this study show that adaptive capacity is recognized as a determinant of physical risk on the municipal bond market. To my knowledge, this is the first study to show that adaptive capacity is recognized as a determinant of physical risk on a financial market.

A limitation of this study relates to the relatively small sample of 38 physically exposed counties, which could possibly give rise to spurious resuls. The small sample is a consequence of limited availability of physical risk data and limited availability of time. The methodological approach used by Goldsmith-Pinkham et al. (2021) is more time-intensive, but can be used to circumvent the limited availability of phyical risk data. This approach can be used in future research to assess whether the empirical results of this study correctly reflect the relationship between adaptive capacity and annualized issuance cost.

This study shows that the mitigating influence of adaptive capacity on physical is recognized and priced on the municipal bond market. A question that naturally follows is whether adaptive capacity is efficiently priced. To answer this question, a probabilistic assesment of the relationship between adaptive capacity scores and adaptation implementation is necessary. This would give adaptive capacity the economic value required for the assessment of efficient pricing. The coefficient estimates of this study could then be used to assess whether adaptive capacity is efficiently priced. This is relevant to know for Congress and the Securities Exchange Commission, who oversee the municipal bond market and question whether an extension of disclosure laws is necessary. If climate change risks are already efficiently priced, such an extension is uneccessary.

Future research should assess whether the pricing of adaptive capacity extends to the commercial and residential real estate market. The inundation risk of a certain property is not only determined by its elevation, land subsidence, and land rebound, but also by the local ability to take effective adaptation measures. To correctly assess whether inundation risk is priced on the real estate market, all these determinants should be taken into account.

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APPENDIX

Table 1 *Adaptive capacity of counties. The selection of coastal cities is obtained through the supplemental file of Hallegatte et al. (2013). The counties associated to these cities are obtained through Painter (2020). The adaptive capacity scores are obtained through the Urban Adaptation Assessment database of the University of Notre Dame*.

City	County	Adaptive capacity
New Orleans, LA	Orleans, LA	0,521
Miami, FL	Dade, FL	0,396
Tampa, FL	Hillsborough, FL	0,402
St. Petersburg, FL	Pinellas, FL	0,412
Virginia Beach, VA	Virginia Beach, VA	0,469
Boston, MA	Suffolk, MA	0,690
Baltimore, MD	Baltimore/Baltimore City, MD	0,498
Los Angeles/Long Beach, CA	Los Angeles, CA	0,219
Santa Ana, CA	Orange, CA	0,239
New York, NY	Bronx/Kings/New York/Queens/Richmond, NY	0,465
Newark, NJ	Essex, NJ	0,421
Providence, RI	Providence, RI	0,337
Philadelphia, PA	Philadelphia, PA	0,571
San Francisco, CA	San Francisco, CA	0,685
Oakland, CA	Alameda, CA	0,799
Houston, TX	Walker/Montgomery/Liberty/Waller/Austin/ Harris/Chambers/Colcrado/Wharton/Fort Bend/Galveston/Brazoria/Matagorda, TX	0,532
Seattle, WA	King, WA	0,746
Washington D.C.	District of Colombia	0,530
San Diego, CA	San Diego, CA	0,635
Portland, OR	Multnomah, OR	0,561
San Jose, CA	Santa Clara, CA	0,646

Table 6 *Detailed descriptive statistics for the second sample of municipal bonds. The categorical variables for municipal bond type and tax provision are excluded from the table. The municipal bond data is obtained through Bloomberg. The sample includes 4,092 observations of bonds that are issued between in 2019 and have an issue size above 1 million US Dollar. Municipal bonds are excluded from the sample if they lack data on their gross spread, yield at issuance, and S&P credit rating. The data on the adaptive capacity of the county of issuance is obtained through the Adaptation Assessment Database of the University of Notre Dame.*

Variable	**Mean**	**Median**	**St. Dev.**	**Min.**	**Max.**	**Skewness**	**Kurtosis**
Annualized Issuance Cost (%)	2.802	2.778	0.505	1.784	6.107	0.501	4.439
Annualized Gross Spread (%)	0.024	0.020	0.017	0.005	0.228	3.290	24.366
Yield at Issuance (%)	2.778	2.75	0.501	1.77	6	0.487	4.348
Adaptive Capacity	0.488	0.485	0.142	0.219	0.846	-0.134	2.901
Amount Issued (M$)	14.286	4.935	28.741	1.01	500.455	6.725	75.483
Maturity	20.926	19	4.741	16	46	1.306	4.426
Rating	3.445	3	2.021	1	13	1.272	5.025
Insured	0.134	0	0.341	0	1	2.150	5.624
Method	0.282	0	0.450	0	1	0.968	1.937
CUSIPS per Issue	17.352	18	9.581	1	52	0.643	3.663
Number of Leads	792.533	857	423.481	11	1318	-0.347	1.887

Table 7 *Correlation coefficients for the second sample of municipal bonds. The categorical variables for municipal bond type and tax provision are excluded from the table. The municipal bond data is obtained through Bloomberg. The sample includes 4,092 observations of bonds that are issued between in 2019 and have an issue size above 1 million US Dollar. Municipal bonds are excluded from the sample if they lack data on their gross spread, yield at issuance, and S&P credit rating. The data on the adaptive capacity of the county of issuance is obtained through the Adaptation Assessment Database of the University of Notre Dame.*

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**
1. Issuance Cost	1								
2. Adaptive Capacity	0.006	1							
3. Log(Amount)	-0.032	0.040	1						
4. Maturity	0.304	-0.017	0.335	1					
5. Rating	0.266	0.003	0.069	0.123	1				
6. Insured	0.149	-0.116	-0.099	0.046	0.247	1			
8. Method	0.073	-0.057	-0.107	-0.042	-0.204	0.021	1		
9. Number of CUSIP	-0.132	0.052	0.016	-0.156	-0.110	-0.207	0.104	1	
10. Number of Leads	-0.035	0.068	0.047	-0.022	-0.067	-0.040	0.023	0.164	1