Signaling Climate Resilience to Municipal Bond Markets: Does Membership in Adaptation-Focused Voluntary Clubs Affect Bond Rating?

Inhwan Ko
University of Washington https://orcid.org/0000-0003-4787-1666
Aseem Prakash (aseem@uw.edu)
University of Washington https://orcid.org/0000-0002-7364-0135

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Abstract

This paper examines whether U.S. cities' membership in voluntary climate clubs improves the municipal bond ratings issued by S&P, Moody's, and Fitch. We suggest that only clubs focused on climate adaptation could help cities signal their resilience to climate risks and their ability to service their municipal bonds. Yet, club membership is only a signal of intent. By itself, it does not offer concrete evidence that cities have adopted adaptation policies or enhanced their resilience to climate risks. We examine three climate clubs: ICELI, whose membership obligations cover climate and other environmental issues; the C40 club, whose scope covers both climate mitigation and adaptation; and the 100 Resilient Cities (100RC) program, which focuses on adaptation only. Employing a two-way fixed effects model for a panel of 80 U.S. cities from 1995 to 2018, we find that 100RC membership leads to a small improvement in bond ratings. This has important policy implications: assurances about implementing adaptation policy, as opposed to evidence about how adaptation reduces climate risks, could have spillover effects on municipal finance. In such cases, climate adaptation could have tangible implications for city-level finances.

1. Introduction

Clubs or voluntary environmental programs are institutions that obligate their members to adopt policies beyond the law's requirement (Arora and Cason 1996; Khanna and Damon 1999; Prakash and Potoski 2006; Darnall 2006). Thus, club membership constitutes a signal of members' commitment to specific policies and practices to outside stakeholders. If some stakeholders want to reward actors who have adopted such policies, this signal provides a low-cost mechanism to differentiate adopters from non-adopters. Yet, it is less clear why actors pledging to follow specific policies with tangible private costs will not shirk or cheat. Thus, in the absence of evidence that actors followed the promised policies and that such policies changed their behavior, outside stakeholders may not find the club membership signal credible.

We contribute to the voluntary regulation literature by examining a relatively understudied issue: club membership's spillover effects or co-benefits (Henriques et al., 2013; Lim and Prakash, 2017). Scholars have noted that clubs that aim to improve members' environmental performance might have unexpected consequences for, say, labor issues. Scholars note the co-benefits of climate policy for issues such as public health (Mendez 2015; Mayrhofer and Gupta 2016; Karlsson et al. 2020). Co-benefits could have the characteristics of public goods and/or private goods that accrue to club members only.

In the context of climate policy, we examine whether cities might secure co-benefits in municipal finance (credit ratings) when they join climate clubs. There is emerging literature examining the relationship between adaptation policy and credit risks (Rashidi et al. 2019). We offer a statistical test of whether cities' voluntary *commitment* to adaptation policies signaled through club membership affects their municipal bond credit ratings. Yet, we also recognize that this is a less likely outcome because the bond rating agencies may not have evidence about whether the city honors its club obligations or that adaptation policies have enhanced the city's resilience to climate risks. Thus, our paper offers a test of the co-benefits of club membership signal, even in the absence of evidence about the club's effectiveness in shaping members' climate resilience.

Climate policy has two pillars: mitigation (reducing greenhouse gas emissions or enhancing carbon sinks) and adaptation (improving social and economic resilience to climate-induced changes). Mitigation policies create a global public good but impose local costs because sectors with high carbon footprints face higher regulatory burdens. Some industries, such as coal, face the prospect of getting shut down completely. While mitigation policies can create local benefits such as green jobs and reduce local air pollution, it is less clear how their *climate* benefits can be reaped at the local level. In contrast, adaptation policies tend to have characteristics of local public goods (Dolšak and Prakash 2018) because adaptation is expected to enhance the local capacity to cope with extreme weather events or rising sea levels, which disrupts the local economy and damages the community's fiscal health.

Cities can finance their efforts to enhance climate resilience through floating municipal bonds. By some accounts, the first municipal bond was issued in 1812 by the City of New York to construct canals from the Hudson River to Lake Erie and Lake Champlain (Cestau et al. 2019). According to the Federal Reserve, the U.S. municipal bond market is an important pillar of city finance, with a market capitalization of over $3.9 trillion as of the fourth quarter of 2020. There is emerging literature on green municipal bonds and debt instruments that provide funding for cities to undertake projects that enhance sustainability (Hilbrandt and Grubbauer 2020). However, our paper focuses on a different question: How membership in climate clubs might affect the ratings of the city-issued bonds to finance *any* municipal-level projects, ranging from schools to infrastructure projects. Rashidi et al. (2019) note that cities might need about $5.5 trillion of new debt every year for their infrastructure needs. They note that even a 0.1% reduction in interest rate could save $5 billion per year. Given that municipal bond ratings affect interest rates (Rubinfield 1973), even a small change in municipal bond ratings could confer non-trivial savings to cities.

Bond-rating agencies, the actors pronouncing authoritative judgments on municipal bonds' future risk levels and the ability of cities to service their debts, are expected to review the city's future fiscal capacity carefully (Cantor and Packer 1996). In other words, they assess if the city will have the economic resources to service its debt and repay the principal. Climate adaptation is relevant here. Because climate change disrupts local economies and imposes enormous costs, cities must prepare to deal with the specific climate threats they might face. For example, cities must build sea walls or invest in managed retreats from low-lying areas to address sea-level rise. To deal with inland flooding, they must reinforce river embankments. And to deal with the heat-island effect, they must invest in more green spaces and planting more trees. With appropriate adaptation policies, cities will be better positioned to deal with the climate challenge without significant economic disruption.

Do then bond rating agencies such as Standard and Poor (S&P), Moody's, and Fitch provide higher ratings for bonds offered by cities with climate adaptation plans, *irrespective* of the purpose for which bond monies are to be used, and without concrete evidence about the effectiveness of cities' climate adaptation policies? Of course, bond rating agencies might simply ask cities for adaptation-related information. What if they do not, or they find it difficult to benchmark the information cities provide? Cities might also face the challenge of credibly communicating their commitment to adaptation to the municipal bond market. We suggest that cities could accomplish this communication goal by voluntarily joining climate clubs (Weischer et al. 2012; Nordhaus 2015; Hovi et al. 2016; LaRovere 2017) that obligate them to adopt climate adaptation policies.

Climate clubs vary in their focus: some target climate mitigation, others adaptation, some incorporate elements of both, and some include non-climate environmental issues along with climate issues. Might bond markets differentiate among different obligations climate clubs impose on their member cities? One might argue that as long as a city is taking climate issues seriously, as demonstrated by joining any type of climate club, it is signaling lower risk in the future and a stronger fiscal capacity to service its debt. Alternatively, bond markets might be more discerning and only associate a lower fiscal risk profile with cities in adaptation-focused clubs. Finally, there is a possibility that bond markets will ignore membership in any type of club; after all, club membership does not constitute evidence that cities have implemented specific climate policies or these policies have enhanced cities' resilience to climate risks.

To arbitrate the debate on whether bond markets reward cities that (1) join any climate club or (2) only those that join adaptation-focused clubs, or (3) not reward at all, we examine a panel of 80 U.S. cities from 1995 to 2018. We focus on three city-level climate clubs: ICLEI (International Council for Local Environmental Initiatives) (Yi et al. 2017), C40 Cities Climate Leadership Group (C40) (Lee and Van De Meene 2012), and 100 Resilience Cities (100RC) (Leitner et al. 2018). The logic of our case selection is that while ICLEI has the broadest scope because its membership obligations cover both climate and other environmental issues, 100RC has the narrowest scope because it focuses on climate adaptation only. C40 incorporates obligations covering both mitigation and adaptation. We take advantage of this variation across climate clubs. Specifically, we examine whether cities' membership in one or more clubs might affect the municipal bond ratings issued by S&P, Moody's, and Fitch. Our analysis suggests that rating agencies modestly reward cities that join 100RC but *not* other climate clubs. Thus, the municipal bond market appears to recognize the policy signal of superior future fiscal health only from municipal borrowers that focus on adaptation.

We recognize that unobservable factors might drive club membership and superior bond ratings. To address a potential endogeneity issue, we test the relationship between 100RC membership and bond ratings using the difference-in-difference (DiD) estimator to address endogeneity issues. We leverage the fact that 21 cities in our sample joined 100RC simultaneously in 2013. We find support for the parallel trend on bond ratings of the treated group (club members) and the non-treated group (non-members) before 2012. 100RC members begin to show higher bond ratings in relation to non-members after 2013. Our DiD estimators show that compared to non-members, 100RC membership saw modestly improved bond ratings issued by all three rating agencies. This provides additional confidence to the finding that bond markets reward cities that have joined adaptation-focused clubs.

The rest of the paper is structured as follows. Section 2 provides a theoretical discussion on the relationship between city-level climate clubs and municipal bond ratings. Section 3 summarizes our data and research methods, and Section 4 reports the results. Finally, we conclude in Section 5 by providing theoretical and empirical implications of our findings.

2. Municipal Bonds, Climate Resilience And Climate Clubs

2.1. Municipal bonds and climate risks

Bond markets provide the platform for investors and borrowers to transact. Investors seek assurance that the borrowers will service the debt and repay the principal in the future. Borrowers want investors to judge their specific attributes instead of simply grouping all borrowers in a single category. Bond-rating agencies provide information on borrowers (bond issuers) based on the ex-ante probability and magnitude of financial distress that the borrower might face in the future, affecting their ability to service debts (Pogue and Soldofsky 1969; Ang and Patel 1975). Thus, bond ratings quantify the risk faced by the lender, who can then price the risk into the cost of borrowing (Hand et al. 1992). Of course, credit rating agencies can misprice risk and provide higher than warranted ratings leading to lower borrowing costs), as evidenced in the 2007-2009 housing market crash (for a review of problems of rating agencies, see: White 2011). Nevertheless, bond ratings remain a crucial pillar of the municipal bond market.

While scholars have tended to focus on private and sovereign borrowers (Holthausen and Leftwich 1986; Goh and Ederington 1993; Hite and Warga 1997; Biglaiser and Staats 2012), cities increasingly use municipal bonds to finance local infrastructure policies (Spence et al. 2008; Cestau et al. 2019). Municipal bonds are of two types: General Obligation (G.O.) bonds are rated according to cities' overall taxation ability. Revenue Bonds are assessed based on how borrowing entities can generate additional revenue from the funded projects (Omstedt 2019).

To assess the ability of the city to service its debt in the future, bond rating agencies consider factors such as demography, governmental policy, fiscal health, and the structure of the local economy (Palumbo and Zaporowski 2012). Climate risks are relatively new factors contributing to the uncertainty about the city's future fiscal capacity. Climate risks are of two types: transition risks and physical risks (Agliardi and Agliardi 2021). Transition risks are costs imposed on cities (and businesses within the city) as regulations compel them to reduce greenhouse gas emissions. Some businesses might even shut down, as is taking place in coal mining communities, imperiling the city's fiscal health. New regulations might flow from governmental mandates, or, in some cases, cities might voluntarily adopt such policies. If a city wants to reduce emissions from, say the transportation sector, it will need to rethink its transportation policy. For example, it might need to invest in public transportation or provide charging stations for electric vehicles. All such policies will impose short-term costs. While they could lower the city's carbon footprint and local pollution levels, it is less clear how they will enhance the city's future capacity to service its debt.

In contrast, physical risks pertain to damages to physical infrastructures from climate-induced events such as rising sea levels, inland flooding, heat waves, and water scarcity. Cities may need to say build sea walls, elevate their coastal roads, create new water purification or desalination infrastructure, or invest in managed retreats. These would impose short-term costs, but they might create long-term local benefits by enhancing a city's long-term resilience.

Credit rating agencies are growingly aware of potential climate risks in making rating actions. In 2019, S&P published a report that discusses the impact of transitional and physical risks to private firms' bonds (S&P Global 2019). FTSE Russel, a London-based credit agency affiliated with the London Stock Exchange Group, is now publishing *FTSE Climate Risk-Adjusted World Government Bond Index* to incorporate climate risks into bond risk assessment practices. In 2020, Moody's announced that it would incorporate climate risk data provided by its research affiliate Four Twenty Seven in the ratings process for U.S. commercial mortgage-backed securities. Also, international development banks such as Asian Development Bank (ADB) note that "[g]overnments must climate-proof their economies and public finances or potentially face an ever-worsening spiral of climate vulnerability and unsustainable debt burdens" (Asian Development Bank 2019). A 2021 S&P Global Ratings report noted, "In some ways, cities are between a rock and a hard place in terms of financing their debt," Spiegel-Feld said. They need to limit development in areas prone to flooding, for example, but also need the property tax revenue from building on valuable land" (Coleman-Lechner, 2021). For instance, in 2014, S&P has announced the credit assessment of the city of Oak Park in Michigan as *watching*, referring to a potential negative impact from a series of litigations the city government was facing due to its lack of preparedness for significant rainfall. Also, Hurricane Harvey that struck the Texas coast in 2017 has led to the downgrade of credit ratings among its neighbors, such as the city of Orange and Rockport. S&P stated in its rationale that 60 percent of residents were displaced which may lead to "tax-base deterioration, revenue declines, and uncertainty with regard to its budgetary performance and flexibility following the effects of Harvey" (Bailey and Brush 2020).

2.2. Signaling urban climate resilience to bond markets with climate club membership

Unlike national-level climate policies, city-level climate policies tend to be less visible and systematic in documenting climate risks (Forsgren, 2018). This is probably because cities have few incentives to do so. Gotham and Faust (2019) note that urban adaptation plans require rebuilding and improving city infrastructures and collecting information on potential climate risks. This is a costly exercise that many cities may not be able to afford.

What if cities choose to invest in adaptation and communicate their intentions to outside stakeholders? This is where the role of voluntary climate clubs becomes important. Cities have been active in establishing and joining clubs. Typically, these clubs obligate (or encourage) cities to adopt and document specific types of climate policies (Gordon, 2020). In return, club membership allows cities to credibly signal their commitment to climate policies to outside stakeholders who lack information on city-level climate policies. This signal has the characteristics of a club good in that non-members cannot use it (i.e., it is excludable), but it is non-rival among its members, for the reputational benefits that one club member receives do not undermine benefits to other members (Cornes and Sandler 1996; Prakash and Potoski 2006).

Climate clubs have different objectives and therefore provide different types of signals to the bond market. Some clubs focus on mitigation issues while others on climate resilience or adaptation. Some clubs might include a range of climate and non-climate issues. These signals highlight varying levels of preparedness of the city to economic and social disruption in the future from climate events. Unlike mitigation, whose benefits tend to have characteristics of global public goods, adaptation policies create local benefits. Therefore, adaption-focused clubs rather than mitigation-focused (or more generally environmental clubs) provide a stronger signal of the city's ability to deal locally with future climate events.

However, it is not clear if bond rating agencies differentiate climate clubs by their varying scope and therefore associate different levels of risks to municipal bonds issued by their member cities. To examine this issue, we consider three climate clubs: 100RC, ICLEI, and C40. Why focus on these clubs? We seek to ensure variation in the club scope: climate-environment nexus club at one end, clubs covering both mitigation and adaption in the middle, and adaptation-focused clubs on the other end. Also, we make no claims that cities have implemented specific climate adaption policies as obligated by their club membership. Scholars note the issue of shirking, where firms may join clubs but may not honor the membership obligations. For scholars, this is more likely to take place when clubs lack effective monitoring and enforcement mechanism (King and Lenox 2000; Rivera and DeLeon 2004; Delmas and Keller 2005; Morgenstern and Pizer 2007; Berliner and Prakash 2016). Our paper does not engage the debate on whether club membership is associated with cities that have improved climate resilience. We are interested in club membership as a signal to the outside world that cities are taking climate policy issues seriously. External stakeholders may view this as climate-washing, where cities join climate clubs but not honor club obligations. In that case, bond ratings will not be affected by club membership. However, if adaptation-focused clubs are indeed associated with higher credit ratings, it will provide some support for the claim that external stakeholders differentiate between different types of climate obligations and are willing to reward cities that have joined adaption-focused clubs, even in the absence of information about club effectiveness in enhancing climate resilience. We offer three hypotheses:

Null hypothesis: Membership in any climate club will not affect credit rating.

Hypothesis 1: Membership in a climate-focused club will improve credit rating.

Hypothesis 2: Membership in an adaptation-focused club will improve credit ratings.

2.3. Case Selection

100RC is a club of 100 cities (including 24 U.S. cities) launched in 2013 that focus predominantly on urban resilience to climate risks. With total funds of $885 million raised by Rockefeller Foundation, a private foundation that sponsored the club, 100RC requires cities to appointed Chief Resilience Officers (CROs) and local coordinators to support highly localized projects for improving urban resilience and develop a common set of indicators such as the City Resilience Index (CRI) to monitor their performance (Galderisi et al. 2020). This is a closed membership club; the club sponsors selected 100 cities from the pool of more than 1,000 cities that applied for its membership.

Founded in 2005, C40 is a network of 96 cities (14 U.S. cities) that aims to promote climate policy coordination among members, focusing on mitigation and adaptation initiatives. Its main function is to disseminate best practices about climate policies among its members (Gordon 2020). C40 and 100RC are comparable in terms of membership size (96 cities, of which 14 are in the U.S.) but differ in their scope. Consequently, we predict that the strength of the C40 signal on preparedness for climate risk will be lower than that of 100RC signal.

In contrast to 100RC and C-40, ICLEI has a substantially bigger membership of more than 1,750 local and regional governments. It covers climate adaptation and mitigation as well as broader environmental issues such as waste, air pollution, and urban congestion (Lee 2013). Overall, we predict that the strength of the ICLEI signal about climate resilience will be weaker in relation to C40 and 100RC due to its broader scope. Table 1 summarizes each climate club and our expectations on how bond markets might perceive the signal about climate resilience.

3. Data And Methods

Following Dove (2015), our objective is to examine the top 100 U.S. cities in terms of their population size. Collecting data on bond ratings proved challenging. U.S. Census Bureau's Statistical Abstract of the United States provides municipal bond rating data (separately for the three rating agencies) from 1995 to 2010. For the post-2010 period, we collected municipal bond rating data directly from S&P, Moody's, and Fitch. Eventually, we constructed a balanced panel covering 80 cities for the period 1995-2018. Upon publication of this paper, we will make this data publicly available to support future research on this important subject.

Our dependent variable is the average of three standardized General Obligation (G.O.) bond ratings provided by S&P, Moody's, and Fitch. The reason is that rating agencies assess G.O. bonds based on the cities' future fiscal capacity. In contrast, revenue bonds are evaluated based on the extent to which borrowing entities can generate additional revenue from the funded projects (such as toll revenue from a new toll road). Because we seek to study how membership in climate clubs might signal a city's overall preparedness to deal with future climate events, G.O. bonds are the appropriate instruments to study.

One can ask why focus on credit ratings of municipal bonds, not borrowing costs (interest rates)? The reason is that interest rates vary by the characteristics of each bond cities float, which makes us hard to interrogate the relationship between borrowing costs and climate club membership. However, G.O. credit ratings are the outcome of judgments made by rating agencies based on their risk assessment of the borrowers in general based on all current bonds they have floated so far. Therefore, if the municipal bond market is sensitive to climate risk cities face and climate club membership provides information on how much they climate-proof themselves, which is what we argue, we expect that rating agencies will be among the first-movers to consider membership status of municipal borrowers and reflect it in their G.O. rating actions.

Following Rubinfield (1973), we suggest a direct relationship between credit ratings with borrowing costs and construct the dependent variable following these steps. First, since all bond ratings are in terms of letter grades (i.e., A+, A.A., B-), we transformed bond *ratings* into numeric *scores* based on the scale they use. S&P has 22 lettered grades ranging from AAA (highest) to CC (lowest). Moody's uses 21 lettered grades ranging from Aaa to C, and Fitch uses 19 lettered grades ranging from AAA to D. For S&P, since A+ is the 18th rank from the lowest, we transformed A+ into the numeric score of 18, which we refer to as bond ratings as "bond scores."

Each bond rater uses a different scale: A score of, say, 18 for S&P provides a different risk assessment in relation to the same score for Moody's or Fitch. Hence, we standardized each bond score assigned by any rating agency based on these means and standard deviations of the rating this agency has provided for any bond in our dataset. Finally, for each city-year, we averaged the three standardized bond scores to get a single numeric score.

The key independent variables of interest are three dummy variables that indicate whether a city was a member of each city-level climate club in a given year. We assign the value of one if a city-year was a member of a specific climate club and zero otherwise. As the literature suggests, several additional factors can affect a city's future fiscal health, both in its tax revenue and expenditures, and therefore bond ratings (Fisher 2013; Peck 2012; Omstedt 2020). We, therefore, include control variables to isolate the treatment effect of individual club membership. First, we control for population and per capita income as they impact the city's tax revenue base. Second, we control for the percentage share of homeowners in the total population and the unemployment rate (Simonsen et al. 2001; Peng and Brucato 2004; Dove 2015), which bear both in future revenues and expenditures. Lastly, we control for the number of State-level and County-level (Parish-level for Kentucky, Borough-level for Alaska)[1] emergency declarations from the Federal Emergency Management Agency (FEMA) as a proxy for city-year exposure to natural disasters. The intuition is that cities that experience extreme weather events are more likely to join climate clubs. But at the same time, extreme weather events might also affect a city's fiscal capacity and its bond ratings.[2] Since, however, emergency declarations include not only climate-related disasters but also related, such as earthquakes, we consider emergency declarations that are limited to wildfires.[3] Because including emergency declaration pertaining to hurricane and snowstorms do not change our substantive findings, we do not report them in the main model. Finally, we include two-way fixed effects (city and year fixed effects) to isolate the effect of individual club membership on bond ratings.[4] Our model equation is as follows:

$$score_{it} = \phi score_{it-1} + \beta X_{it} + \gamma Z_{it} + \alpha_i + \theta_t + \varepsilon_{it}$$

Where i = 1, 2, ..., 80 is a city index and t = 1996, 1997, ..., 2018 is a year index, *score* is the average of standardized scores from three rating agencies, X is a set of three explanatory variables (membership in 100RC, C40, and ICLEI), Z is a set of control variables, a_i is a unit-fixed effect, Θ_t is a year-fixed effect, and ε_{it} is an idiosyncratic error.

Consistent with the prior literature (Biglaiser and Staats 2012), we include a dependent variable lagged by one year to account for the stickiness of the bond ratings. We recognize the debate on using a lagged dependent variable, which scholars see imposing a downward bias in the estimate (Achen 2000; Keele and Kelly 2006; Wilkins 2018). But we see this as a positive because it makes our estimates conservative. Given the scope of our sample data, we allow for the error terms to be spatially and temporally correlated by using Driscoll and Kraay's standard error, clustered by the state in which cities are located (Driscoll and Kraay 1998; Vogelsang 2012).

Typically, agencies rate bonds at the time of their issue, although they can re-evaluate these ratings at any point in time. In effect, these agencies do not issue new bond ratings for U.S. cities every year. This creates a missing observation problem. To mitigate bias from listwise deletion, we created 100 imputed datasets using the Amelia R package that fills out missing observations with a bootstrapping-based algorithm (King et al. 2001; Honaker and King 2010).[5] Then, we estimate the above two-way fixed effects model with each imputed data set and simulate 100 coefficients with model results, which gives us 10,000 simulated coefficients in total that capture the uncertainty from both the model results and the multiple imputation process. In the next section, we report our results based on these 10,000 simulated coefficients.

3.1. Potential endogeneity issue for 100RC membership

We recognize a potential threat to our causal identification strategy: endogeneity between 100RC membership and bond ratings. After all, the Rockefeller Foundation selected a subset of cities for membership in the 100RC (Gordon 2020). This selection process is a possible source of bias: cities with good standing in terms of fiscal and financial capacity, including higher bond ratings, might have been selected as members of 100RC.

To address this issue, we investigate the effect of 100RC membership on bond ratings through a difference-in-difference (DiD) design. We exploit the fact that all 100RC members joined the club in 2013 and maintained membership afterwards. This simultaneous and lasting treatment separates pre-treatment and post-treatment periods, which allows us to casually identify the DiD estimator of the 100RC membership effect (Angrist and Pischke 2009). We use the following regression to estimate the DiD causal effect:

$$score_{it} = \beta 100RC_i + \gamma POST_t + \delta_{\mathrm{DiD}}(100RC_i \times POST_t) + \varepsilon_{it}$$

Where   is a binary indicator whose value of one means that the ith observation is assigned to a treatment group (i.e., if a city joined 100RC in 2013) and zero otherwise; $POST_t$ is a binary indicator that takes the value 1 when the city joined the club in 2013 (or afterwards) and zeroes otherwise; and variable of interest is δ_{DiD} . In this design, we use not only the standardized bond score but each bond rating of three rating agencies transformed into numeric scores as additional dependent variables.

[1] New York City is located across five counties (Kings, Queens, New York, Bronx, and Richmond) across which its population is almost equally distributed. Therefore, we calculated the number of county-level emergency declarations for New York City by counting (not summing up) all declarations in five Counties. The declarations of other cities which locate in more than two Counties are counted based on the County with the largest population.
[2] ND-GAIN provides indicators for city level exposure to climate-induced risks. Because ND-GAIN data are not provided on an annual basis, it is not useful for a longitudinal study that spans a period of 23 years.
[3] Including three additional types of emergency declaration in our original model, hurricane, flood, and snowstorm, does not significantly change its main findings.
[4] We were unable to find data on city-level cumulative debt burden for a sufficiently large number of cities. Statistical Abstract of the United States provides data for 30 cities only, which is about 38% of cities in 0ur dataset. We believe that introducing fixed effects, along with a lagged dependent variable, will account for idiosyncratic factors associated with municipal debt burden. In addition, we have included year fixed effects which account for year specific fiscal shocks such as the 2007-2008 financial crisis, which would affect any city's fiscal health.
[5] We specified the following conditions to run the algorithm. First, we included all control variables which include county and state-level emergency declarations (all types and wildfire-type only). Next, we excluded our three independent variables (membership for 100RC, C40, ICLEI) to mitigate a possible bias from multiple imputation. Also, we allowed lags and leads of bond ratings (by one year) to be correlated with bond ratings in each year to account for the fact that bond ratings are sticky across time. Lastly, we allowed for bond ratings to flexibly change over time by assuming cubic time effects of all variables included in the imputation algorithm.

4. Results

Figure 1 reports the 10,000 simulated coefficients of each covariate used in the two-way fixed effects model. We find support for Hypothesis 2: among the membership of three climate clubs, only the membership in 100RC is statistically significant with an average effect of 0.172, and the standard error of the distribution of 10,000 simulated coefficients is 0.065. This means that 100RC membership increases the bond ratings approximately by 0.19 standard deviation units given the distribution of standardized bond rating scores of all observations in 100 imputed data sets. The average effects of neither C40 membership nor ICELI membership are statistically significant.[6] This supports the hypothesis that

100RC, which primarily focuses on adaptation (Hypothesis 2), will improve bond ratings instead of ICELI or C40 (Hypothesis 1).

Among other variables, the lagged dependent variable (bond score in the previous year) is significant, implying the stickiness of the bond ratings. All other control variables did not have a significant effect ($p<.05$), while coefficients for the population (logged) and per capita income (logged) have wider confidence intervals. This result reflects two types of uncertainty in coefficient estimates that commonly appear in empirical research design with imputed datasets: uncertainty from a statistical model and multiple imputations. Nevertheless, the coefficient for the 100RC membership has a narrower confidence interval, which leads us to suggest higher confidence in our main finding.

What if cities join multiple climate clubs? Will the effect of membership in a given club be conditional on membership in other clubs? To examine this, we estimate two additional models. First, we included two-way interaction terms (100RC*C40, 100RC*ICELI, C40*ICLEI) in our model, which is consistent with figure 1 but also controlling for all types of county-level emergency declaration. Second, we included a three-way interaction term (100RC*C40*ICLEI) in the same model above. In both models, while 100RC membership variable persists in showing positive ($\hat{\beta}$=0.196; 0.195) and statistically significant (t-statistics: 2.002; 1.873) coefficients, none of the interaction terms, be they two-way or three-way, show statistically significant results.

Next, we report the result of the difference-in-difference analysis. The first step is to establish whether there is a parallel trend in bond ratings between the “treated” 100RC members (21 U.S. cities) and non-100RC members (69 U.S. cities) before 2012.

Figure 2 presents four plots that use different dependent variables to check the robustness of this parallel trend. The upper left plot uses the average of standardized scores from three rating companies. The other three plots use a plain numeric score transformed from the lettered grade based on the metric that each of the three rating firms uses. Two solid lines in each plot represent the average outcome variable by year whose color differentiates the group of non-100RC members (dotted-red) and 100RC members (solid-blue) across all 100 imputed datasets. The above plots reveal that the parallel trends exist in all four plots between non-100RC and 100RC members before 2012. Yet, these trends change after 2013 when 100RC members joined this climate club. Indeed, while previously non-RC members had higher average bond ratings in relation to R.C. members, after 2012, R.C. members started having higher ratings.

Table 2 reports the DiD estimators, their statistical significance, and 95% confidence intervals for all four dependent variables, collected from results using all 100 imputed datasets. Overall, DiD estimators are positive and statistically significant; Fitch rating is significant at 90% confidence level only, and this is consistent with Figure 2, where the difference in Fitch rating score (bottom right plot) between 100RC member group and non-member group after 2013 is the smallest. This provides additional evidence that bond markets believe that 100RC membership offers some assurance that cities will adapt climate adaptation policies which will eventually improve their capacity to service future debt. For instance, in 2015 in rating city of Norfolk’s bond as “Aa2” (the third highest), Moody’s referenced 100 RC’s Resilient

Strategy. The same strategy was applauded by S&P when it raised Norfok's s credit rating to AAA in 2019, the highest possible rating it grants to borrowers (City of Norfolk 2019).

[6] Changing the dependent variable into three bond ratings issued by each rating agency does not significantly change the main findings of our original model. Specifically, the average effect of 100RC membership (and its 95% confidence interval in brackets) in S&P bond rating score is 0.467 [0.055, 0.864], that in Moody's is 0.477 [0.040, 0.864], and that in Fitch is .440 [0.017, 0.883]. None of the coefficients of C40 or ICLEI membership are statistically significant.

5. Conclusion

Cities increasingly rely on bond markets to provide capital for infrastructure investment. Bond investors seek assurances that cities will not default; that is, they will have the fiscal capacity to service their debt and repay the principal[7] – after all, municipal bond defaults are not uncommon occurrences (Cestau et al. 2019). How then do bond investors seek information about the long-term fiscal health of the city? This is where bond rating agencies come in by providing this information to investors via bond ratings. Yet, bond raters do not (yet) formally consider a cities' preparedness to address climate issues, be it sea-level rise, heat waves, or water shortages. Do they do so informally? We examined how climate clubs might signal this information to rating agencies. Our analysis supports the argument that bond rating agencies modestly reward those cities that have joined adaptation-focused climate clubs, although they do not evidence that club membership has enhanced climate resilience. Thus, even a weak signal of assurance about climate adaptation seems to persuade bond markets about a cities' capacity to service its debt in the future.

Our paper makes several contributions to the voluntary club literature that are an important part of the governance tool kit. While climate club membership offers a general reputation signal about members' commitment to climate stewardship, stakeholders might want information on a specific subset of issues. This means that clubs should designed with a specific functional purpose, perhaps even catering to specific stakeholders. In terms of the population ecology of clubs, we should expect to see functionally specialized clubs start displacing more general-purpose reputational clubs slowly.

Our paper highlights another dimension that may influence the contribution of a club to public policy goals: co-benefits or spillover effects which could have the characteristics of either private benefits cornered by benefits or public benefits that flow to the society. For example, in comparing the effectiveness of ISO 14001 and the Clean Industry club in the context of Mexico, Henrique et al. (2015) find that the Clean Industry club, with its more stringent obligations and superior monitoring mechanisms, was more effective in reducing emissions of specific toxins targeted by the club. In addition, it was more effective in reducing the emissions of non-targeted greenhouse gas emissions, which are outside the club mandate. Thus, the club membership created a spillover benefit with public good characteristics. Lim and Prakash's (2014; 2017) show how membership in ISO 9001 quality control club had a spillover effect of reducing labor accidents, a public good, while membership in ISO 14001 environmental club had a spillover effect of enhancing innovation in terms of patent counts, that have both private and public good dimensions. Our paper has identified another type of spillover effect, with predominant private good features: improving bond ratings when cities join an adaptation-focused club.

This paper raises questions for future research. While 100RC membership constitutes a signal that cities are committed to adaptation, it is unclear if cities' climate resilience improves after joining 100RC. Investigating such questions requires a widely accepted measure of adaptive capacity, such as the index developed by ND-GAIN. Only then could we evaluate how club membership influenced the stated goals of club performance.

This paper examined two clubs, 100RC and C40, with small membership rosters and ICELI, with a larger membership roster. Future research could examine how membership size affects the strength of the club signal. Small membership could enhance the club's reputation especially if high entry barriers limit the membership roster. But smaller size also means that the club will have less visibility and serve as a weaker signal to differentiate members from non-members. Thus, the issue of optimal club size (Cornes and Sander 1996) depends on the club objectives and the specific mechanism through which club membership affects the reputation of its members.

Finally, we recognize that our study is limited to U.S. cities, three climate clubs, and G.O. bonds. Hence the generalizability of our findings should be tested on additional cities (within and outside the U.S.), new climate clubs, and other types of bonds, especially on climate bonds. Moreover, future research should investigate if our key findings also hold for country-level and firm-level climate clubs. After all, the risk of climate change and the importance of climate resilience is critical for all actors, not just cities. The financial sector could facilitate rapid decarbonization of the economy if it rewards actors – cities, national governments, or firms – for their climate actions. Our paper provides some initial evidence that the financial sector is fulfilling this role.

[7] While credit rating agencies provide tool to bond holders to price the credit risk, bond holders also face a risk from a rise in interest rates which can devalue the bond, given that it is a fixed interest bearing security. This is a systemic risk which credit ratings cannot help the bond holder to price into the value of the bond.

Declarations

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Conflict of Interest

The authors declare no conflict of interest.

Data and code availability

Upon the publication of the paper, the authors will make the data and the code available at the Harvard Dataverse.

Authors’ contribution

The first author has retrieved and refined data, devised the statistical models and ran the code to run the models. The second author has written and refined theoretical arguments and provided discussion on findings.

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Tables

Table 1. Club Scope and Signal about the Future Fiscal Capacity to Service Debt

Club	Scope	Strength of the adaptation preparedness signal
Resilient Cities 100	Focused on adaptation	High strength: bond rating agencies should reward cities that have joined this club
C40 Cities Climate Leadership Group	Covering both mitigation *and* adaptation	Moderate signal strength: bond rating agencies may or may reward cities that have joined this club
International Council for Local Environmental Initiatives	Covering climate (mitigation and adaptation) *and* broader environmental issues	Weak signal: bond rating agencies will probably not reward cities that have joined this club

Table 2. DiD estimation results complied from 100 imputed data sets

	Standardized bond score	S&P rating	Moody's rating	Fitch rating
DiD estimator	.283**	.701**	.741**	.591*
95% CI	[.065, .505]	[.066 1.334]	[.076, 1.382]	[-.039, 1.203]

Note: **- p<.05; *- p<.1. We used a heteroskedasticity-consistent standard error for all models.

Figures

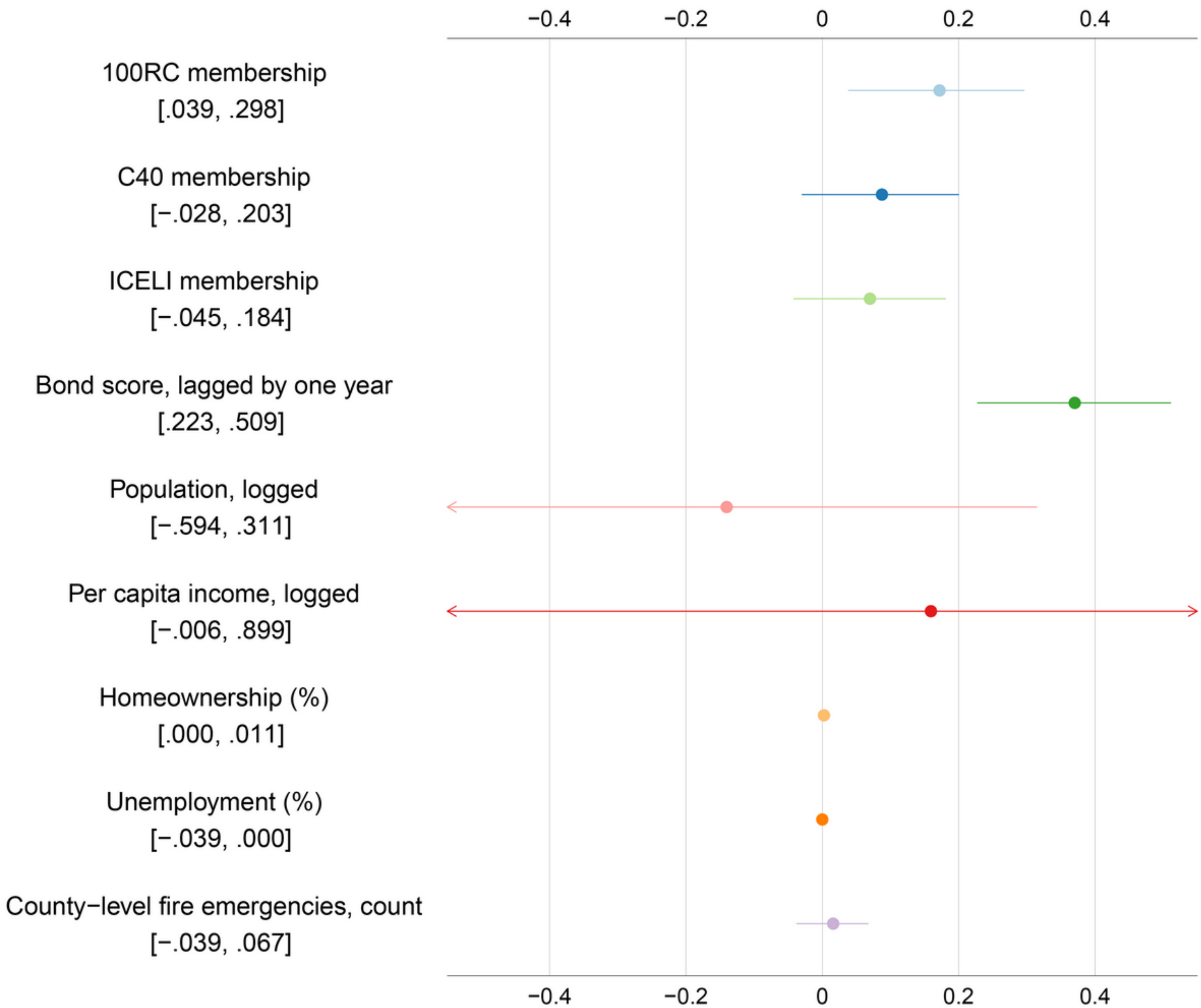

Figure 1

Margial effects of each covariate on average bond score (95% CI)

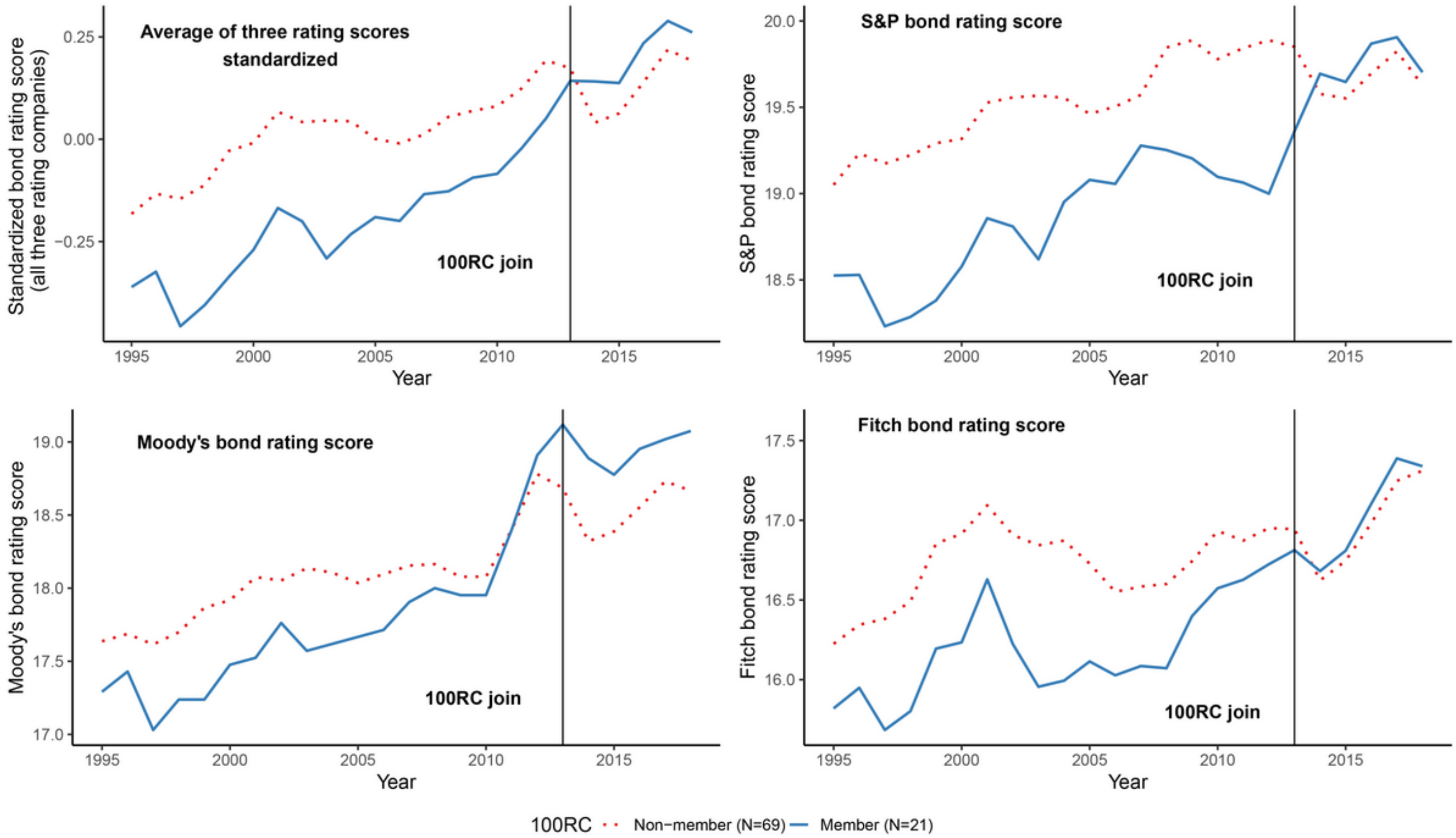

Figure 2

Small multiples of parallel trends in bond ratings between 100RC members group non−members group