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Grassroots vs. greenhouse: the role of environmental organizations in reducing carbon emissions

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Abstract
Why do some communities see fewer greenhouse gas emissions than others? This study examines the intervening role of environmental NGOs in Japanese urban emissions between 2005 and 2017. We draw from all 1741 Japanese municipalities, testing the effect of grassroots NGOs on emissions, and demonstrating different pathways to reducing emissions through the cases of three environmental organizations. While past studies have examined the role of social ties in environmental governance outcomes like emission reduction efforts, the direct roles of grassroots organizations have not yet been explored in a mixed methods design. We find that cities with more local grassroots organizations and multi-level organizations tend to see fewer emissions over time, a compelling endorsement of civil society efforts to avert climate change. This study aims to build a theory on what kinds of environmental NGOs promote climate change mitigation.

Keywords Nonprofit · Emissions · Climate · Civil society · Environmental policy · Japan

1 Introduction

Why do some communities see greater reductions in carbon dioxide emissions over time than others? This question rankles scholars and policymakers hoping to keep their counties in line with Paris Accords targets. Past studies highlight that emission reductions depend on population carbon footprints (Xi et al. 2020), economic dependence on carbon (Long et al. 2018a), socioeconomic and demographic inequalities (Lesbirel

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1998; Taylor 2014; Forastiere et al. 2007; Kasuga and Takaya 2017), governance capacity (Rabe 2004), and the value of civil society engagement in environmental governance (Aldrich 2008; Hager & Haddad 2015). In particular, studies highlight that local bureaucrats with close ties to environmental organizations adopt more aggressive climate policies (Portney and Berry 2013; Fraser et al. 2021a), and communities with greater social capital and organizing capacity reduce more emissions (Fraser et al. 2020). However, environmental organizations' direct effects on emission reductions are less well understood. Do emission reductions depend primarily on cities' capacity to mobilize? Or, do greater densities of *environmental organizations* propel cities forward to reduce their carbon footprint, and how much?

This mixed methods study empirically tests the effects of grassroots environmental organizations on climate change mitigation through greenhouse gas emission reductions. We focus on Japanese carbon dioxide (CO2) emissions, recorded by the Ministry of Environment (MoE) from 2005 to 2017 in all 1741 municipalities, combining geographic information systems (GIS), statistical modeling, and short descriptive case studies of three types of environmental organizations comparing different pathways to emission reductions.

This study makes three major contributions to the field. First, we find that environmental organizations such as co-ops, nonprofits, and public interest associations are typically associated with declining rates of total and industrial emissions in Japanese cities. This builds on past studies, which highlighted that civil society organizations and social capital help accelerate climate change mitigation (Pennington & Rydin 2000; Portney & Berry 2013; Hager & Haddad 2015; Fraser et al. 2020).

Second, we also find that environmental NGOs that provide networking and support for other organizations, concentrate on conservation, recycling, and community development, and operate at prefectural, regional, and national levels are frequently related to *significant declines* in emissions. As demonstrated in our case studies, these NGOs use ties to multiple organizations and government offices to apply pressure and identify local mitigation projects. This adds to past literature, which suggested that organizational networks help energize environmental regulation (Broadbent and Ishio 1998; Lee and Painter 2015; Bulkeley 2006; Fraser et al. 2021a).

Third, this study introduces a new publicly available dataset estimating spatially smoothed rates of environmental NGOs per 1,000 residents, for every municipality in Japan between 2005 and 2017. These rates subdivide into 34 categories in terms of volunteer participation, legal status, issue areas, activities, site of operations, and budget size. While past studies have catalogued the traits of environmental organizations in Japan before through national surveys (Environmental Restoration and Conservation Agency 2020), this study creates new measures scholars and policymakers can use to identify cities with a wealth or dearth of environmental activism.

2 Literature review

Why do some communities see lower greenhouse gas emissions than others? Past studies identified five major determinants of cities' ability to reduce emissions, including (1) economic and demographic conditions, (2) socioeconomic conditions, (3) governance capacity, (4) community mobilization, and (5) grassroots environmental organizations.

2.1 Demographic and economic conditions

First, some communities face steeper hurdles when combatting climate change due to the carbon footprint of their economies and populaces. Population density (Xi et al. 2020) and depopulation (Long et al. 2018a), explicitly worsened by Japan's aging population, both have been identified as emission-boosters in Japanese cities (Li et al. 2021). Furthermore, in addition to high intensity emissions from manufacturing, agriculture and household consumerism produce indirect emissions (Long et al. 2018b). Although specific household habits, like meat-consumption, affect carbon footprints somewhat, households' carbon footprints depend more on varied consumption from vegetables, fish, alcohol, and restaurant food, lifestyle factors more commonly associated with differences in socioeconomic status (Kanemoto et al. 2019). Furthermore, constituencies like workers in raw materials or manufacturing sectors have vested interests in maintaining their industries' status quo, meaning that in regions where these constituencies proliferate, policymakers face less incentive to combat emissions or must barter with trade unions and companies (Thomas 2021). These companies frequently oppose or hedge against regulation (Meckling 2015).

2.2 Socioeconomic conditions

Second, some communities may face fewer emissions due to greater socioeconomic status. Wealthier, highly educated communities may see greater rates of rooftop solar adoption and more progressive environmental policies than poorer, less well-educated communities, a key distributive justice issue (Jenkins et al. 2016; Taylor 2014). Economically downtrodden communities historically tend to host more controversial, polluting, and often-carbon intensive facilities (Lesbirel 1998; Taylor 2014; Aldrich 2008; Aldrich & Fraser 2017), because they offer jobs and immediate income to residents. Correspondingly, poorer residents tend to see higher rates of mortality than their wealthier peers due to air pollution accompanying fossil-fuel use (Forastiere et al. 2007). Alternatively, communities with greater socioeconomic inequality often receive less community pressure for environmental governance, lacking time and financial resources available to mobilize (Kasuga and Takaya, 2017). There are some exceptions; residents with higher socioeconomic status may also lead more carbon-intensive lifestyles (Wilson et al. 2013), where purchasing power translates to more electricity, gasoline, and shipping (Kang et al. 2020). These socioeconomic determinants may produce strong cleavages in carbon emissions across Japanese cities.

2.3 Governance capacity

Third, some communities reduce emissions more than others due to stronger governance capacity, meaning bigger budgets, better staffing, and stronger institutions with which local governments can enact policies (Rabe 2004). Examples include the early success of Tokyo's cap-and-trade policy (Takao 2016, 2012), emissions trading systems in Chinese cities (Biedenkopf et al. 2017), Californian state climate policy (Carlson 2014; Meckling and Nahm 2018), and Japanese pollution regulations in the 1970s onwards (Avenell 2012a, 2012b).

2.4 Social capital and community mobilization

Fourth, even communities with low socioeconomic status and weak government capacity might reduce emissions given sufficient social capital to mobilize residents (Pennington & Rydin 2000; Portney & Berry 2013). Social capital, the social ties that enable trust, reciprocity, and collective action, comes in three forms: bonding, bridging, and linking social capital (Aldrich & Meyer 2015).

Bonding social capital describes close-knit in-group ties among friends, family, and neighbors, usually of the same race, ethnicity, age, gender, or socioeconomic status. Bonding ties are frequently utilized in Not-In-My-Backyard (NIMBY) campaigns to repel unwanted industrial facilities from neighborhoods (Hager & Haddad 2015), but tend to be inwardly focused.

Bridging social capital describes bridging, inter-group ties among members of different social groups, usually from different racial, ethnic, age, gender, or socioeconomic backgrounds (Putnam et al. 1993). Bridging ties build reciprocity and shared stake in one's community, built through membership in associations (Pekkanen et al. 2014), and encourage mutual aid and civic participation (Haddad 2012). These ties are linked to better disaster recovery (Aldrich 2012), reduction in ethnic violence (Varshney 2002), new community initiatives like renewable energy (Fraser et al. 2021a, b), and CO2 mitigation (Fraser et al. 2020).

Linking social capital describes vertical ties to local, regional, and national authorities, which residents use to access public goods (Tsai 2007), especially in times of crisis (Aldrich 2019). Linking ties might be a panacea, helping residents accelerate renewable energy transition and reduce carbon emissions, or they might limit mitigation, directing resources to maintain investment in communities related to fossil fuel interests. These three types of social capital levy distinct effects on communities' ability to avert carbon emissions, although research on Japanese cities suggests that stronger bonding and bridging ties are linked to lower emissions (Fraser et al. 2020).

2.5 Environmental organizations

Finally, we hypothesize that the density of environmental organizations in a city might help city officials reduce emissions. Japan is home to a vibrant culture of grassroots civil society organizing over environmental issues. In post-war Japan, widespread industrial pollution triggered a community-based environmental movement focused on anti-pollution (kōgai tōsō), comprising residents, farming and fishing cooperatives, and religious associations (Hasegawa 2004; Avenell 2012a, b). Victims of pollution scandals, like methyl-mercury poisoning in Kumamoto and Niigata, Itai-itai disease, and Yokkaichi asthma, claimed compensation from the Japanese government, led to mass protests, and propelled the Japanese Diet to establish the world's most stringent environmental protections at the time in 1970 (Hoshimo, 1992; Avenell 2012a, b; Hasegawa 2014). During the same period, residents' associations organized to protest nuclear power plant siting in their communities, concerned about environmental justice issues and compensation (Hasegawa 2004; Aldrich 2008).

These diverse grassroots organizations continued to organize against industries polluting neighboring farmlands to combat and deter pollution (Mitsuda 1996). By the 1980 and 1990s, following UN conferences on the environment, development, and human rights, Japanese environmentalists reoriented their attention to global environmental problems (e.g., the 1992 Rio Earth Summit), leading to new NGOs (Avenell 2017). In 1998, the Non-profit Organization (NPO) law was passed, allowing civil society organizations to incorporate, and have their own bank account, with more favorable taxation (Pekkanen 2006). Due to no legal status for NPOs before 1998, Japan built fewer national-level environmental organizations (such as the Sierra Club in the USA) than other industrialized democracies, but after the NPO law, at least 3000 groups incorporated as NPOs between 2001 and 2005 alone (Tsujinaka et al. 2007). Grassroots environmental activism surged further after the disaster at Fukushima Daiichi Nuclear Power Plant (Mikami 2015; Aldrich and Fraser 2017; Oguma 2016; Cassegard 2018), and new policies in 2012 helped advance renewable energy, decrease electricity consumption, and decrease greenhouse gas emissions.

We hypothesize that these environmental organizations might help cities make meaningful reductions in their emissions. Activists might pressure lawmakers to stop the construction of new coal power plants and industrial facilities, encourage consumers to use less electricity, reduce waste and streamlining recycling, build renewable power plants, and help connect communities and companies with new sustainable development opportunities.

3 Methods

Why do some cities see greater reductions in greenhouse gas emissions than others? This study tests the effect of environmental non-governmental organizations (NGOs) on emissions, controlling for communities' capacity to mobilize, city governance capacity, and socioeconomic, demographic, and economic conditions. We focus on all 1741 municipalities in Japan, using an expansive dataset of carbon emissions per 1,000 residents. From 2005 to 2017, the Japanese Ministry of Environment (2020) tracked each city's annual carbon emissions in kilotons of CO2 in 14 categories, including (1) total emissions, (2) consumer emissions, comprising (3) household and (4) business emissions, (5) industrial emissions, comprising (6) manufacturing, (7) construction/mining, and (8) agriculture, forestry, or fisheries-related emissions, (9) transportation emissions, comprising (10) automobile, (11) truck, (12) railroad, or (13) boat emissions, and finally, (14) waste emissions. As our outcome, we calculated the *annual rate of each type of emissions per 1,000 residents per municipality*. (Fig. 1 summarizes these rates of emissions on average, as well as their most frequent intervals). We compare models with qualitative analysis of three types of environmental organizations, discussed further below. Below, we introduce our (1) variables, (2) modeling strategy, and (3) qualitative case selection strategy.

3.1 Measuring the density of environmental organizations in Japan

This study develops new measures of the density of environmental NGOs in Japan. We rely on a nationwide survey of environmental organizations, surveyed in 2016 and released in 2019 (Environmental Restoration and Conservation Agency 2020). Japan's Environmental Restoration and Conservation Agency (ERCA), a branch agency of the Ministry of Environment, surveyed the full universe of 18,000 environmental organizations with bases in Japan that carry out activities related to environmental conservation. This was broadly defined to include anything from forest conservation to recycling to global warming prevention and even energy savings.

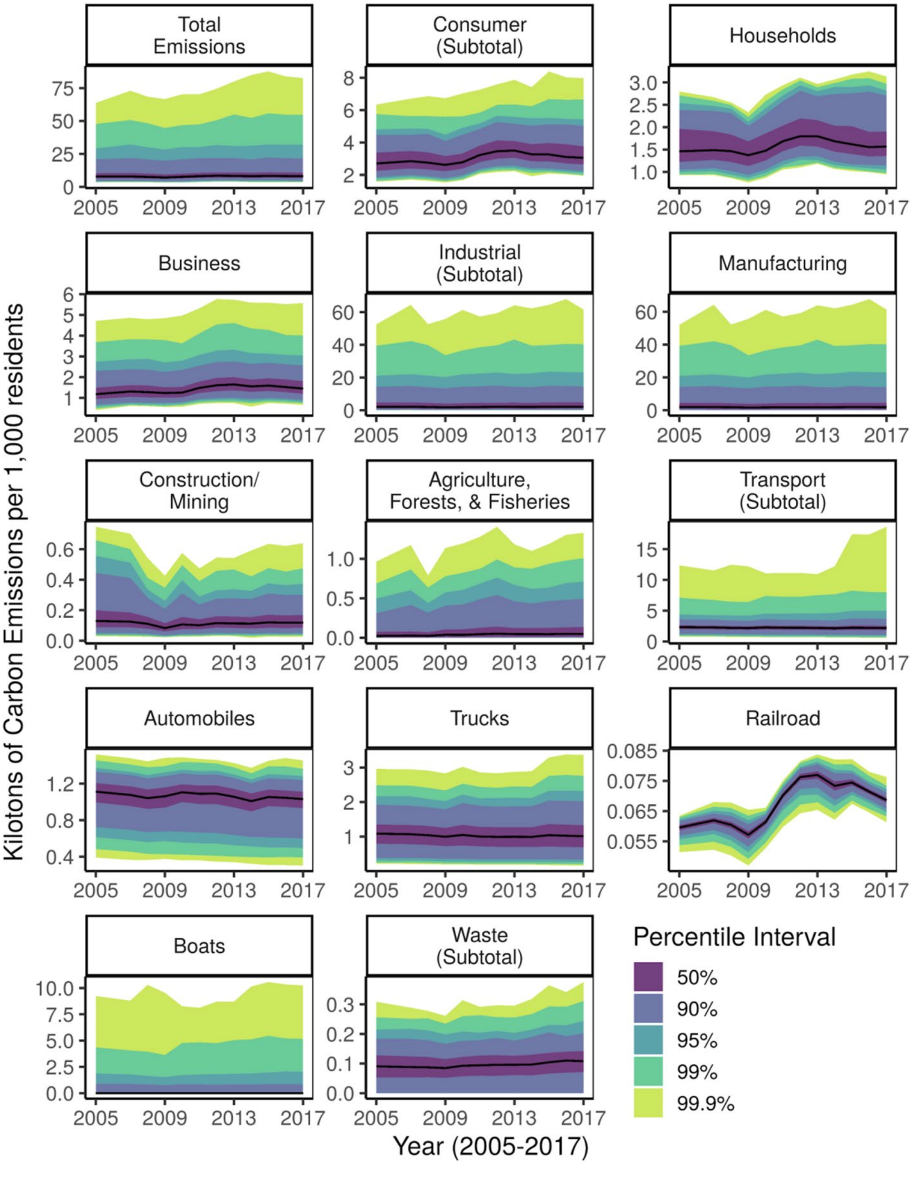

Fig. 1 Carbon emission rates over time in Japanese municipalities. Caption: Solid black line depicts median city's emission rate annually, while bands reflect percentile ranges (50% = 25th to 75th percentiles, 90% = 5th to 95th percentiles, etc.)

These organizations included (1) registered non-profits whose reported activities include environmental conservation, (2) those registered in the Public Interest Commission of Japan's cabinet Office, including organizations aimed at preserving the global environment or protecting and improving the natural environment, (3) NGOs registered through various Japanese government information platforms, including the Global Environmental Partnership Plaza or Environmental Partnership Office, (4) organizations which applied for the JQA Global Environment Fund between 2013 and 2015, and (5) all other organizations registered in ERCA's preexisting environmental NGO database, compiled from a 2013 survey.

This survey of over 18,000 organizations produced responses from 3,989 environmental NGOs in Japan, constituting approximately 22% of surveyed organizations. The original list of surveyed organizations was not shared for privacy reasons; consequently, little data exists to assess *how* representative this sample is. Since the survey was government-run and participation represented a publicity opportunity with no known drawbacks, organizations likely did not respond because they were inactive. When compared against alternative databases, we found that ERCA survey measures cover the most environmental NGOs but closely correlates with alternative measures (see Appendix D). We utilize this dataset as the best-known approximation of "active, responding" environmental NGOs currently available in Japan. We geolocated 3,911 organizations which reported their municipality of origin in Japan (98%), and then tallied the total number of environmental organizations active annually per 1,000 residents, using their year of incorporation. For 92 organizations' (2%) missing years of incorporation, we imputed 2005, ensuring these are counted in every year's cumulative tally.

However, this tally has two limitations. First, it represents 22% of surveyed environmental organizations; some communities might be undercounted due to response bias. Second, many environmental organizations involve activists and operations not just in one city but also neighboring cities. To account for this, we use *spatial interpolation*, a common geospatial analysis technique to *smooth* population-controlled rates of environmental organizations across nearby geographies. Using a fishnet grid, we spatially smoothed rates over every 30 km^2 grid cell ($n=763$) (the median municipality is 123 km^2, meaning 4 cells fit into it). This size cell was chosen to create a map that better reflects geographic diversity between and across cities. We then averaged per municipality the rate of environmental organizations based on interpolated rates from all cells *within* or *overlapping* with city limits. Figure 2 illustrates our process, from left to right.

Finally, we divided rates of environmental organizations by *type*, using six categories, including (1) volunteer base, (2) legal status, (3) site of operations, (4) issue area, (5) budget size, and (6) activities conducted.

First, for volunteer base, we categorized organizations based on the number of volunteers involved, using survey-provided categories of 0, 1–5, 6–10, 21–50, and 51 or more (visualized in Appendix C3).

Second, for legal status, we categorized companies using 9 types of legal incorporation, including voluntary groups, co-ops, nonprofit organizations (NPO), social welfare foundations, general foundations, public interest foundations, public interest associations, incorporated associations, or "other."

Third, for site of operations, we classified organizations as operating (1) in one municipality, (2) in and surrounding their designated municipality, (3) in their designated prefecture, (4) in and surrounding their designated prefecture, (5) nationwide, or (6) another location or abroad.

Fourth, for issue areas, out of 736 reported interest areas (many redundant or overlapping), we qualitatively coded each organization using a hierarchical schema based on what issues are hypothetically most related to emission activism. This included (a) climate or energy, (b) recycling or consumption, (c) environmental education, (d) machizukuri (community development), (e) conservation, or (f) another field. Fifth, for budget size, we classified organizations into three categories, spending 1 million yen or more a year (about $9,000 USD), less than 1 million yen, or unspecified amounts.

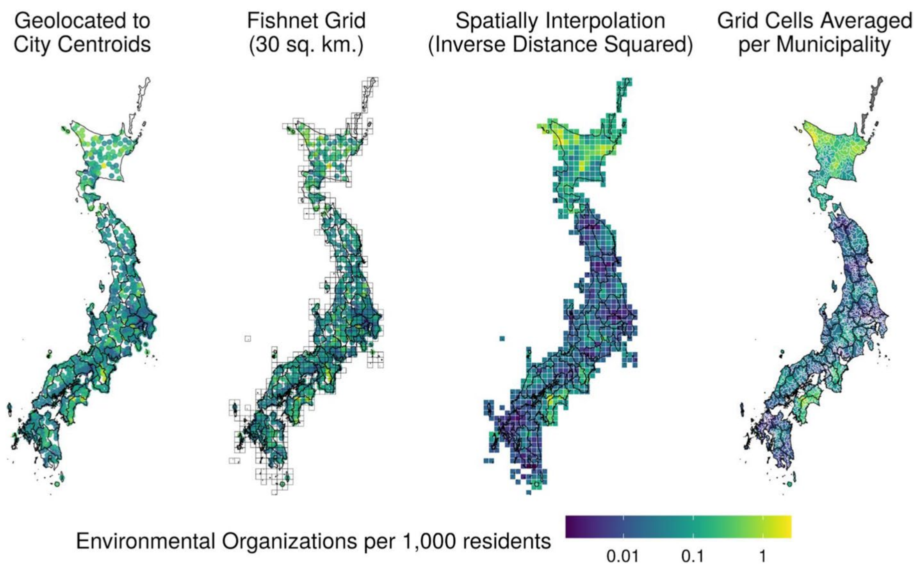

Fig. 2 Spatially smoothed rates of environmental NGOs per municipality. Caption: Displays rates in 2017. Interpolation was conducted each year (2005 to 2017)

Sixth, for activities conducted, out of 51 possible types of activities, we coded using the 7 most commonly reported activities, each appearing 232 to 3042 times, where the next largest category appeared only 11 times. We then consolidated these into 4 topically distinct categories, including (1) practical activities, (2) policy advocacy and information dissemination, (3) networking and support for other groups, or (4) research. These different categories of environmental NGOs helps us see in greater detail *which kinds* of environmental organizations matter most to emission reduction efforts.

This study also relied on 14 control variables to account for alternative explanations for changing emissions, including bonding, bridging, and linking social capital indices, governments' financial capacity, educational levels, income per capita, unemployment, population density, median age, employment in the primary and secondary sectors, and economic production in agriculture, commerce, and manufacturing. We describe these in depth in Appendix A: Methods (continued).

3.2 Modeling strategy

Using the assembled variables, this study applied a two-pronged modeling approach, using (1) panel OLS models and (2) difference-in-differences OLS models. First, we used panel OLS models to test the *direct effect of total environmental organizations* on emission rates over time, controlling for each of the aforementioned control variables, while accounting for correlated residuals over time using fixed effects by year. (Fixed effects fit better than random effects, for which there were not enough cases to apply random effects given the number of necessary covariates.) For total emissions, we repeated this basic model 7 times, using different combinations of environmental NGO measures, to test the effect of (Table A1) total environmental NGOs per 1,000 residents, then (Table A2) environmental

NGOs broken down by size of volunteer base, (Table A3) by legal status, (Table A4) site of operations, (Table A5) issue area, (Table A6) budget size, and (Table A7) activities conducted. We expected that some environmental organizations are more effective at emission reductions than others. In each model, we log-transformed both the outcome variable, emission rates, and the rate(s) of environmental organizations, because these are extremely right-skewed variables; all visuals back-transform results appropriately.

Second, we turned to *difference-in-difference* (DiD) OLS models to estimate the *changing* effect of rates of environmental organizations on emissions. DiD models use interaction effects between the main variable of interest (rates of environmental NGOs) and an annual counter over time (0–13) to reveal how much we expect the emission trajectories to differ over time given different rates of environmental NGOs and their activism. Simultaneously, we control for the direct effect of environmental NGO rates and the baseline effects of each year via annual fixed effects. We apply an interaction to each measure of environmental organizations, listed in Tables B1, which depicts the effect of total environmental NGO rates, and Tables B2-B6, which each depict one of the six subclassifications of environmental organizations.

Finally, we use statistical simulation in the Zelig package in R. We project the expected change in emissions as rates of environmental NGOs vary from low levels (its 20th percentile) to high levels (80th percentile), holding other variables constant at their means. We conducted this analysis not just for total emissions, but for all 14 emission measures, totaling 96 panel models and 96 DiD models. Scholars can examine each model in the replication code, but for brevity, each model contains the same covariates, displayed in Model Tables A1-A7 and B1-B7 and described above.

3.3 Case selection

Finally, we examined three types of environmental organizations through short demonstrative qualitative case studies, using Lieberman's (2005) *nested analysis*. Following the logic of nested analysis, we paired our large-N analysis with small-N case studies of cases *well-predicted* and *poorly predicted* by our models, to better understand these models' strengths and limitations. As well-predicted, "emblematic" cases, we examine the local grassroots environmental organization Mitaka Action and the multi-level networking organization Kikō Network. As a poorly predicted, "divergent" case, we examine the national level organization, the Institute of Sustainable Energy Policy. We examine these further in the "Discussion."

4 Results

This study examined effects of environmental organizations on emission rates using panel OLS and difference-in-differences models, drawing from spatially smoothed cumulative rates of active environmental NGOs between 2005 and 2017. Below, we summarize key, statistically significant results ($p < 0.05$) from our analysis, which covered 96 panel OLS models and 96 difference-in-differences models, focusing on 14 types of emissions and 7 ways of categorizing environmental organizations. Since interpreting effects of log-transformed variables (environmental NGO rates) on log-transformed outcomes (emission rates) is often unintuitive, we used 1000 statistical simulations in the Zelig package to simulate expected differences in emission rates, as environmental NGO rates increase from lower levels (20th percentile) to greater levels (80th percentile), holding other variables at their means, with 95% confidence intervals. All simulated effects discussed were statistically significant ($p < 0.05$), meaning their simulated 95% confidence intervals never crossed zero.

4.1 Direct effects of environmental organizations

First, we examined direct effects of environmental organizations, using panel OLS models. When a community's rates of environmental NGOs increased from the 20th percentile to the 80th percentile, we saw the following effects (depicted in Figure A1). As hypothesized, only some types of environmental organizations were related to decreasing emissions; total environmental NGOs were only negatively related to transportation (− 0.06), truck (− 0.04), and waste (− 0.01) emission rates. Otherwise, NGOs were unrelated or linked to *increases* in total emissions (0.7).

When we categorized environmental organizations by type, interesting distinctions emerged. Communities with more *nonprofit organizations* tended to see fewer emissions from industry (− 0.12 kilotons per 1,000 residents), manufacturing (− 0.15), automobiles (− 0.01), and waste (− 0.01). This effect was stronger among *co-ops*, which saw fewer emissions in total (− 0.55 kilotons per 1,000 residents), from industry (− 0.51), manufacturing (− 0.33), automobiles (− 0.03), and trucks (− 0.01). *Public interest associations* demonstrated the largest negative effect, revealing fewer emissions in total (− 1.27 kilotons per 1,000 residents), for consumers (− 0.26), households (− 0.13), businesses (− 0.12), industry (− 0.39), manufacturing (− 0.24), and smaller decreases for waste (− 0.01). Many such effects were shared among *public interest foundations*, which saw emissions decrease for consumers (− 0.14 kilotons of carbon per 1,000 residents), households (− 0.07), businesses (− 0.06), construction or mining (− 0.01), and waste (− 0.01).

Several other types of organizations were linked to emission reductions. Organizations with 21 to 50 volunteers tended to see fewer emissions in total (− 0.64 fewer kilotons per 1,000 residents), for consumers (− 0.3), households (− 0.15), businesses (− 0.13), construction or mining (− 0.01), and waste (− 0.01). This effect persisted for organizations with 51 or more volunteers, leading to decreases in emissions in total (− 0.26 kilotons per 1,000 residents), for industry (− 0.11), manufacturing (− 0.03), and transport (− 0.04).

Organizations active in their prefecture and surrounding region tended to see lower consumer (− 0.37), household (− 0.21), and business (− 0.14) emissions. Furthermore, organizations active in climate and energy tended to see lower consumer (− 0.08) and business emissions (− 0.09), while groups focusing on recycling and consumption experienced lower consumer (− 0.17), household (− 0.1), and business (− 0.06) emissions. Most organizational activities were unrelated to emissions decreases, with networking and policy advocacy occurring more in locales with higher total emissions. However, networking was related to decreases in transportation (− 0.18) and truck emissions (− 0.14), interestingly.

In Fig. 3, we highlight simulated effects of three types of environmental organizations frequently linked with fewer emissions. These include nonprofits, co-ops, and public interest associations. We simulated expected emissions in an average city in 2017 as the density of these organizations increases from 1 to 350 NGOs per million residents, the minimum and maximum observed total organizations in any city.[1]

[1] For zero, which cannot be log-transformed, we used a very small constant instead (0.01).

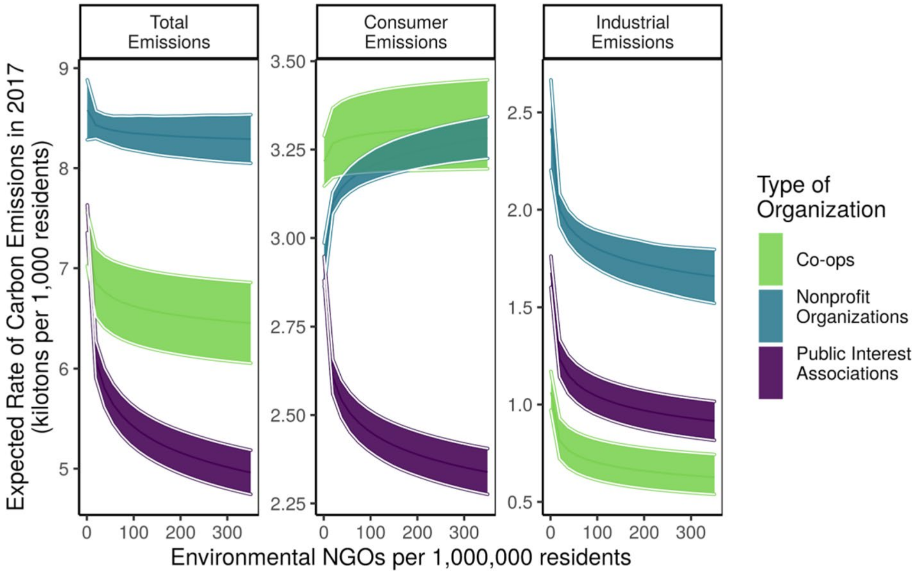

Fig. 3 Key types of environmental NGOs leading to lower emissions. Caption: Panels reflect median expected values with 95% confidence intervals in 2017. Simulated in the Zelig package in R as the rate of each type of environmental organization increases from 1 to 350 NGOs, holding all other traits at their means. Rates of environmental NGOs and expected emissions exponentiated to remove log-transformation

Each led to reduced total and industrial emissions, while just public interest associations were associated with reduced consumer emissions. The divergent effect of co-ops and nonprofits on consumer emissions, like other types of organization not pictured, might reflect that while these groups may mobilize to oppose industrial plants, they may not immediately affect widespread consumer behavior on their own.

4.2 Difference over time due to environmental organizations

Next, we examined results from difference-in-differences models, simulating the expected change in emissions for an average city whose level of a specific type of environmental organization increased from low levels (20th percentile) in 2005 to high levels (80th percentile) in 2017. This analysis finds many strong effects over time statistically significant at the $p < 0.05$ level, meaning their 95% confidence intervals do not cross zero. First, many types of groups led to significant decreases in *total* kilotons of carbon emissions per 1,000 residents over time, including co-ops (−0.68), public interest associations (−1.38), groups with 21–50 volunteers (−1.15) or 51 volunteers or more (−0.79), those active in their entire prefecture (−0.59), those active in multiple countries (−0.63), and those active in conservation (−0.65) or machizukuri community development activities (−0.57). After these, the strongest effects occurred among industrial and manufacturing emissions, followed by transport, automobile, and truck emissions, where nearly every type of environmental organization examined led to decreases in these types of emissions over time. The strongest effects on industrial emissions came from nonprofits (−0.42), co-ops (−0.86), and public interest associations (−0.73); from groups with 50+ volunteers or more

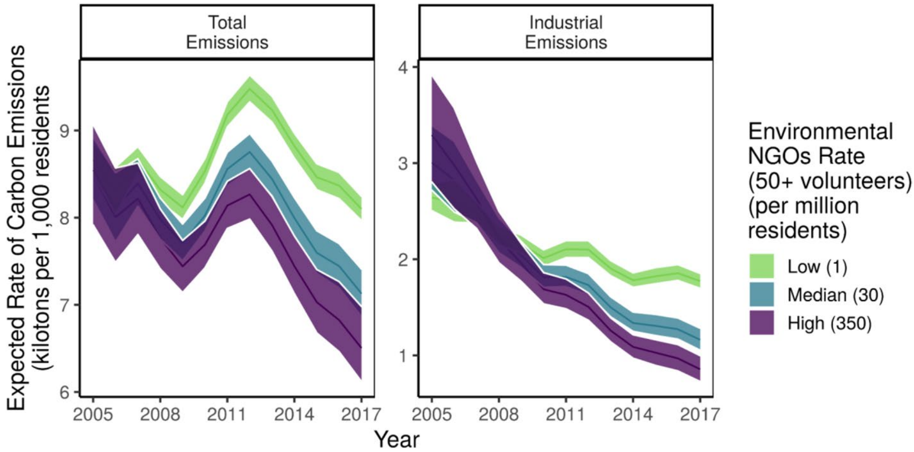

Fig. 4 Volunteer environmental NGOs lead to lower emission rates over time. Caption: Panels depicts median expected emission rates with 95% confidence intervals. Bands reflect interaction over time for the effect of environmental organizations with at least 51 volunteers, given the minimum (1), median (30), or maximum (350) rate of environmental organizations in a city per million residents. Changing slopes represent annual fixed effects

(− 0.93); from groups active in their home prefecture (− 0.85) or abroad or other locales (− 0.95); those focusing on Machizukuri (− 0.87); and those focusing on policy advocacy and information (− 0.76) or practical activities (− 0.79).

Figure 4 depicts this trend using the case of environmental organizations with 51 or more volunteers using 1000 statistical simulations of an average city between 2005 and 2017, varying only the level of this type of environmental organization. This plot reflects expected total and industrial emission rates, which showed statistically significant associations, given the lowest observed rates (1 per million residents), the median rates (30), or the highest observed rates (350) of environmental NGOs in the sample. We see stark changes, where cities with just 1 environmental NGO with high volunteer participation per million residents tend to see *much higher* emissions than peers with the 30 NGOs or even 350 NGOs per million residents, with the gap growing wider with every passing year.

This matches a long history of literature on the role of environmental activism in combatting controversial siting arrangements, like the siting of coal-fired power plants, polluting businesses, or highways and other transportation infrastructure (Hoshimo 1992; Lesbirel 1998; Hasegawa 2004; Avenell 2010; Aldrich 2012; Hager & Haddad 2015). It makes sense that environmental NGOs, especially those with more volunteer participation, would be especially effective at organizing and turning out to oppose the construction and opening of such controversial facilities.

In contrast, results were mixed for consumer, household, and business emissions. Volunteer participation (NGOs with 21–50 volunteers) was also consistently linked to fewer household emissions in both types of models, but consumer and business emissions showed negative effects in fixed effects models (Figure A1) but positive effects in DiD models (Figure B1). Variation in these emissions might be better explained by bonding and bridging social capital and the norms they produce; future studies should empirically test whether environmental NGOs accomplish greater reductions in emissions given greater social capital.

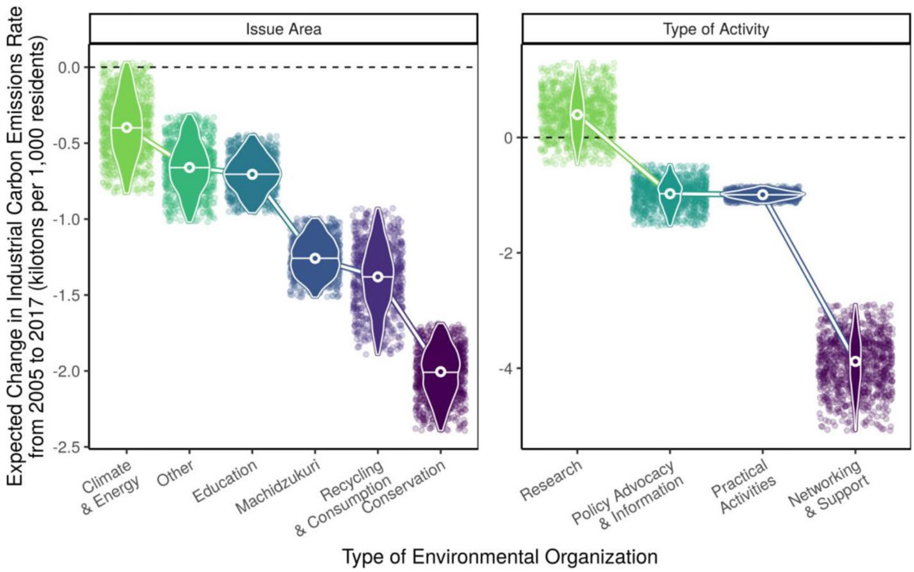

Fig. 5 Change in emissions by environmental organizations' activities. Caption: Jittered points and violins portray simulated expected differences within 95% confidence interval, while point indicates median expected difference. Expected differences calculated from 1000 simulations using the Zelig package in R, holding all other variables at their means, while the rate of environmental organizations conducting a given activity was varied from the sample median of 30 NGOs per million in 2005 to 31 per million in 2017

4.3 Effectiveness of environmental organization strategies over time

Finally, these results raise several questions still. If cities can encourage *certain* kinds of activity from environmental organizations over others, which strategies have been most effective at reducing emissions? We simulated the expected change in industrial emission rates, which had the strongest associations with environmental NGOs among our models. The median city had 30 environmental NGOs per million residents. Then, if a city had 30 environmental NGOs per million residents in 2005 focused on, for example, climate and energy issues, we simulated *how much* would expected emission rates change if they added 1 more of the same kind of environmental NGO by 2017. We repeated this for each issue and activity type, and plotted the distributions of 95% of the most common expected changes in Fig. 5.

Figure 5 highlights the most likely change expected given an increase in that activism strategy. We see that groups focused on conservation had the largest effect on emissions (− 2.02), followed by recycling and consumption (− 1.39) and machidzukuri (− 1.26). Climate and energy focused groups ironically had the least impact, potentially because these are especially active in high emission locales, like urban areas. Alternatively, groups focused on networking and support experienced the greatest effect (− 3.91), followed by practical activities (− 1.00) and policy advocacy and information dissemination (− 1.00).

Using the same approach, we simulated in Fig. 6 the differing effects environmental NGOs have on emissions depending on their geography of operations. Those that operate just within one city tend to have little impact on overall emissions, but considerable

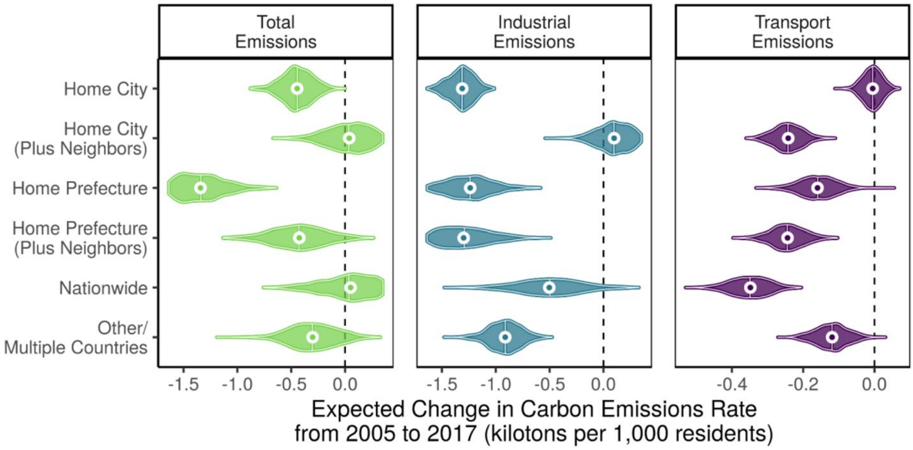

Fig. 6 Change in emissions by environmental organizations' area of operations. Caption: Violins reflect distribution of change in expected emissions, showing values within the 95% confidence interval, while the central line and point indicate the median expected value. Expected values generated from 1000 simulations in the Zelig package in R, varying the rate of each specified type of environmental organization from the overall sample median of 30 NGOs in 2005 to 31 NGOs per million residents in 2017, holding all other variables at their means

impact on industrial emissions, where the addition of a single environmental organization working that city's limits per million over the sample median leads to − 1.31 fewer industrial emissions per 1,000 residents. Others are more consistently effective. Organizations that work on a prefectural level more consistently reduce total emissions by 1.45 emissions or industrial emissions by 1.25 emissions per 1,000 residents. Those operating nationwide or in multiple prefectures are especially effective at combating industrial or and transportation emissions, reducing emissions by between 0.23 and 1.35 kilotons per 1,000 residents.

5 Discussion

In summary, this study found that between 2005 and 2017, the concentration of environmental organizations in Japanese cities made large, meaningful differences in the levels of carbon emissions, depending on the type of organization. We can extrapolate that in cities with more environmental organizations relative to the size of the population, more environmental engagement and also activism may have occurred, with volunteers or employees at these civil society organizations pressuring their local, prefectural, and national officials to reduce their carbon emissions.

This study also found that several types of environmental organizations are especially effective at reducing emissions. First, we found strong evidence that local grassroots organizations can have significant effects on carbon emissions, especially if those organizations are co-ops, nonprofits, or public interest associations, whose effects were strongest on industrial emissions (Fig. 3), and especially if those organizations involved large numbers of volunteer participation (Fig. 4). This builds on past qualitative accounts which indicated that food co-ops are effective organizations for political action, especially among women (LeBlanc 1999), as well as more recent literature on nuclear power politics, where past studies found that grassroots activists have been surprisingly effective at stalling nuclear power plant restarts by using court injunctions and legal tools to achieve their goals (Aldrich & Fraser 2017).

Second, we also found considerable support for the effectiveness of multi-level, networking organizations in climate mitigation, matching prior accounts by Broadbent and Ishio (1998), Lee and Painter (2015), and Fraser et al. (2021a, b). First, we found that organizations active at the prefectural, regional, and national levels are especially effective at reducing industrial and transportation emissions, hinting at the coordination power of environmental organizations that bridge multiple cities and regions (Fig. 6). Similarly, we found that organizations active in networking and supporting other organizations were most effective at reducing emissions (Fig. 5), also adding to our hypothesis that multi-level networking organizations are especially useful.

Third, we saw mixed results for national, institutionalized organizations. Though we expected organizations that focused on climate and energy to exert the strongest negative effect on emission, it actually levied the weakest (Fig. 5), while other more locally focused causes like education, community development, recycling, and conservation were more effective. Furthermore, organizations that operated nationwide or internationally tended to see higher emissions overall, perhaps an artifact of many of them being based in Tokyo, but were related to some decreases in industrial and transportation emissions. These were not as strong results as expected, but this may be because our estimation strategy more clearly captures the effects of local level organizations on their municipality's emissions than national level organizations's effects on the entire country's emissions through national policy change.

However, questions remain as to *how* certain types of environmental organizations led to greater change in emissions than others. Below, we draw on short qualitative case studies of three types of environmental organizations, including (1) *local grassroots organizations*, (2) *multi-level networking organizations*, and (3) *national level organizations* to demonstrate *how* these groups might lead to fewer emissions.

5.1 Emblematic case: local grassroots organizations

One type of environmental organizations well predicted by our models was *local grassroots organizations.* As highlighted in Fig. 4, cities with more groups with high volunteer participation saw considerably fewer emissions over time, controlling for other factors. Similarly, as highlighted in Fig. 5, cities with groups focused on conservation, recycling, or *machidzukuri*—key foci of local level groups—saw much greater reductions in emissions. This raises a puzzle: How do local grassroots organizations impact emissions, given that they typically have low budgets?

One key way local organizations have impacted emissions is by participating in the renewable energy transition. For example, Mitaka Action, a citizen action committee in the Tokyo suburb of Mitaka, was closely involved in early protests, parades, and efforts to collect signatures to oppose the restart of nuclear power plants after the 2011 post-Fukushima shutdown. In the years following 2011, however, a handful of nuclear power plants came back online despite public protests, and members of anti-nuclear organizations throughout the country began considering what alternative ways they could impact demand for nuclear power. Mitaka Action, among others, settled on renewable energy, starting their own small solar power company Mitaka Citizens' Joint Power Generation Association, known today as Mitaka Electric (*Mitaka Hatsuden*). They have built a 28-kW installation on top of a local school, held seminars for local students and residents on how to build household photovoltaics, launched photovoltaic installations in members' households, and regularly conduct PR efforts to promote consumer renewable energy usage.

Mitaka Action is not alone. Throughout Japan, grassroots organizations got involved in the post-Fukushima solar boom, making small but meaningful contributions to early solar adoption. Fukuoka Green Coop, another type of small, volunteer focused organization, built their own 1 MW mega-solar installation along the coast of Itoshima, pooling together coop members' funds and efforts. These examples build on past research which showed that communities with stronger bridging social ties tended to see fewer emissions (Fraser et al., 2020), and local grassroots NGOs' efforts in the renewable energy sector represent an important way that environmental organizations can use such social ties to accomplish their aims.

5.2 Emblematic case: multi-level networking organizations

Another type of organization well predicted by our models was multi-level organizations. As highlighted in Fig. 5, cities with organizations that focused on networking and support or policy advocacy and information saw declines in emissions. Furthermore, organizations active across entire prefectures or regions tended to see declines in emissions, especially for industry or transport (Fig. 6).

This is exemplified by the Kikō Network (気候ネットワーク, literally Climate Network), which represents Japan's oldest and largest non-profit climate network based in Tokyo and Kyoto. Since its establishment in 1998, the network has become the most influential environmental NGO in Japan on climate-oriented issues and decarbonization (Kameyama 2004). For this, they have been involved in environmental issues in the country with a particular focus on the coal issue on the community and local levels by supporting renewable investment and coal divestment. They also disseminate environmental values, engage in environmental education and training, conduct policy research, and submit proposals on the national and international levels (Kikō Network Website 2021). Additionally, Kikō Network's volunteer base ranges from 70 to 90 each year, and their annual revenue is approximately 60 million yen (equivalent to $550,000) (Kikō Network 2017).

In order to increase the visibility of the trend toward renewable energy in Japan, Kikō Network as well as other organizations collaboratively publishes white papers on the environment annually (i.e., Green Watch). They also take active part in domestic networks and platforms (i.e., Climate Action Network Japan), support and advise local governments, launch projects and seminars, create policy proposals, and regularly publish press releases and statements. Furthermore, they organize street demonstrations with members and volunteers. They also monitor the Japan Business Federation (a pro-nuclear and pro-coal industry lobby) and pressure energy and environment-oriented institutions for carbon emission reductions. Kikō Network, like other national and regional environmental NGOs, like the Japan Center for Climate Change Actions, acts as a key networker and coordinator for local movements.

Most concretely, Kikō Network's anti-coal campaigns have helped to achieve a major goal for decarbonization, namely the cancellation of new coal fired power plant construction in Takasago, Hyōgo Prefecture and Ichihara, Chiba Prefecture (Kikō Network 2017). Similarly, environmental NGOs have taken legal actions toward companies to stall the operations of coal-fired power plants, such as a 2018 lawsuit at the Kobe District Court against Kobelco Power's Kobe Power Plant in Hyogo Prefecture, as well as a 2019 suit against plant operator JERA to shutter the Yokosuka Power Plant in Kanagawa Prefecture (No Coal Japan 2021). In these ways, multi-level network organizations can have wide-reaching impacts, helping residents across the country alter the emissions policies of companies and national government offices.

5.3 Divergent case: national level organizations

Finally, one type of organization *poorly* predicted by our models was national, institutionalized organizations. As highlighted in Fig. 6, organizations active nationwide were not consistently linked to reduced emissions, and only somewhat tied to lower industrial or transport emissions. However, our methodology tested only the impacts of environmental organizations *based in a community on that community's emissions.* Therefore, the impact of national organizations based in Tokyo on communities across Japan could be estimated with our modeling strategy. However, past studies did find that each successive year after the 2011 disaster had negative effects on emissions (Fraser et al. 2020).

To investigate how national level organizations affect emissions, we zoomed into the divergent case of the Institute of Sustainable Energy Policies (ISEP) (環境エネルギー政策研究所), an independent, non-profit research organization based in Tokyo. Since its establishment in 2000, it has been led by energy experts and climate change campaigners by providing resources, activities, and services aiming to help Japan transition to sustainable energy.

Headed by environmental policy expert Iida Tetsunari, the organization has been particularly influential advocating for renewable energy after the 2011 disaster. The institute collaborates with the nationwide industrial sectors and city governments, especially with those in Fukushima Prefecture. As an advocacy group, they cooperate with central government representatives, evaluate existing energy policies, and design scenarios under which Japan can reach 100% renewable energy, without relying on nuclear power or coal energy sources.

In addition to their advocacy, ISEP has conducted community-based renewable energy projects, mostly solar PVs, and helped small communities to build small hydro power plants or geothermal heat pumps. One of the most significant works by ISEP is to provide plans for local energy alternatives and emission reduction targets by providing data from regional to national scale. For example, the Japan Community Power Association established in 2014 as the first nationwide network aiming to have region-led renewable energy businesses in Japan, where the ISEP played a role of secretariat (ISEP 2016 Report). As for ISEP, they have organizational and individual membership and gather participation through volunteering and internships.

In this way, national organizations based in Tokyo like ISEP have diffuse effects on emissions across the country, even if their local effects are less clear. Future studies should examine how much municipal emissions decrease nationwide as the rate of national level environmental organizations and their activities increase.

6 Conclusion

In summary, this study examined variation in 14 types of carbon emissions among all 1741 municipalities between 2005 and 2017, testing the effect of environmental organization and specific types of these organizations. We found that local grassroots organizations help reduce emissions, especially co-ops, nonprofits, or public interest associations, or if they have strong volunteer participation, as demonstrated by the case of Mitaka Action. We also found that multi-level network organizations active at the prefectural, regional, or national level help reduce industrial and transportation emissions, as demonstrated by the Kikō Network. Finally, we found limited effects of national level organizations on their locality's emissions, but qualitative accounts of considerable diffuse effects on emissions across the country through large policy changes, as demonstrated by the work of ISEP.

These findings build on past studies, which emphasized the value of civil society organizations and grassroots social capital in climate change mitigation efforts (Pennington & Rydin 2000; Portney & Berry 2013; Hager & Haddad 2015; Fraser et al. 2020), by showing what types of organizations are most effective at reducing emissions in their own municipalities. While qualitative studies have argued that environmental NGOs matter to emission reductions (Hasegawa 2004; Lee and Painter 2015; Hager and Haddad 2015), this is the first study, to the authors' knowledge, that empirically tests *whether and how much* environmental NGOs affect emissions, and *what kinds* of organizations matter the most. While past studies indicated that advocacy efforts are rarer among Japanese NGOs (Pekkanen 2006; Haddad 2012), our results indicate that environmental NGOs are advocating for change, and their advocacy is working, leading to actual reductions in industrial emissions, among others.

This study also came with several limitations. First, we relied on a survey sample of environmental organizations, not the full population of organizations, which are unknown. However, we compensate for this using spatial smoothing, predicting rates of environmental orgs in each city based on neighboring communities. These estimates from 2005 to 2017 are now publicly available for download and use by other scholars studying Japan. Furthermore, validation tests in Appendix D showed largely consistent results when compared against other samples of environmental organizations.

Second, to contextualize model results, we relied on short case studies based on annual reports, news, and secondary literature. However, future research should chart directly how specific projects, like Kikō Network's anti-coal activism, led to coal plant cancellation and its impact on emissions. A clearer understanding of *how* environmental organizations mobilize resources to accomplish their goals could help advance decarbonization efforts, and what actionable interventions countries can make to promote those organizations.

Third, this study examined organizations in terms of their (1) volunteer base, (2) legal status, (3) site of operations, (4) issue area, (5) budget size, and (6) activities conducted, based on survey data available. Future studies should investigate the effects of different institutional structures, as well as informal networks (Broadbent & Ishio 1998; Lee & Painter 2015; Bulkeley 2006; Fraser et al. 2021a), on how these organizations gather volunteers, collaborate with officials, and accomplish change. For example, although volunteer base was consistently linked to fewer total and industrial emissions, our difference-in-difference models also showed positive associations with consumer, household, and business emissions. Further research is necessary to unpack whether and why consumer emissions do not follow the same pattern as industrial emissions. Though Japan's civil society was shaped greatly by legal restrictions until 1998, we anticipate that our findings about local and multi-level organizations' effectiveness may extend to other industrialized democracies. By clarifying the effects of environmental organizations, this study aims to open a research agenda on what kinds of organizations, institutional structures, and networking strategies are most effective for combatting emissions.

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Declarations

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