The Emerging Polycentricity of Subnational Climate Adaptation Networks in the United States

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Abstract:

Climate change is a global issue with highly localized impacts. In the face of national inaction subnational government have taken the lead on climate change policy. While effective mitigation efforts requires large-scale national coordination, some subnational governments have begun to enact adaptation policies to address climate risks within their jurisdictions and to coordinate across jurisdictions. Understanding how cooperation occurs across jurisdictional boundaries is one of the key challenges to designing effective climate policies. Using a national dataset on subnational government climate policy activities, this paper examines what influences whether a subnational government agency has enacted a climate adaptation action. It initially focuses on characteristics of subnational jurisdiction themselves that facilitate or hinder local action. This includes population density, political party vote share, exposure to risk from sea level rise, and intensity of state-level climate planning effort. The model then examines the influence of participation within either a formal or informal climate policy network and the scale of the political jurisdictions that network partners operate. Using a classic definition of political jurisdictions within a federal system this includes partners whose activities are focused on the local urban scale, county, state and national. The final model examines patterns of cross jurisdictional cooperation and whether a network includes members who are explicitly engaged in county-to-county cooperation within or across state boundaries and network partners who are organized to facilitate interstate cooperation. The paper concludes with a discussion of the nature of polycentric governance in climate adaptation policy and the importance of the results for understanding inter-jurisdictional cooperation on climate issues.

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Introduction

As international policy on climate change has stalled, and domestic action faces extreme partisanship and outright antagonism, state and subnational governments have been left on their own to tackle the challenges of both mitigation and adaptation policy. High profile examples, such as the 'We Are Still In' declaration by governors, mayors, county executives, tribal governments, and business leaders dominate the media and provide reminders that subnational activity continues. Less noticed examples of subnational policy activity at smaller scales are also occurring. New York City's recent Climate Resiliency Design Guidelines require climate projections to be taken into account in city facilities planning within the city. The Southeast Florida Regional Climate Compact was formed by county governments looking to cooperate on regional climate adaption. Simply because the executive and congressional branches of the federal government are paralyzed on effective climate policy does not mean the problems communities are facing has disappeared, and subnational governments are evolving new governance structures in response.

Polycentricity offers a theoretical framework through which to better understand the emerging structure of subnational cooperation on climate change. In her 2014 piece, *A Polycentric Approach for Coping with Climate Change*, Elinor Ostrom argued that combination of insufficient trust in international institutional arrangements, inherent free rider problems, and the possibility of gaming policy instruments always meant that international institutions alone would be insufficient to deal with the problem (Ostrom, 2014). She instead suggested polycentricity as an initial step to encourage experimentation, allow for heterogeneity across different ecosystems, and allowing for the development of active oversight by local, regional, and national stakeholders, while building a stronger bottoms-up commitment among local and regional scale governance systems linked through information networks. Similar arguments are made by Cole (2015) that polycentric systems can permit more experimental and learning over time and increase overall cooperation within larger scale system as they develop (Cole, 2015).

Jordan, et. al. (2015) point out that polycentric forms of climate governance are already emerging in dynamic complex patterns across a range of national and subnational settings. They however caution that little is known about how well they may complement international systems, and that there is little evidence of their effectiveness to date (Jordan et al., 2015).

Theoretical research on polycentricity suggests a number of ways more localized action offers benefits over national and even state-level policy. The list of factors includes better information on the fit of policy action to the problem, more direct feedback between the preferences of citizens to decision makers, matching the costs of action to the localized benefit provided, increased legitimacy of local public agencies, among others (Bodansky 2014, Engle and Orbach 2008, McGinnis 1999). Climate change represents a global challenge with highly localized consequences with the impacts diffuse and influencing nearly every sector of the economy, from agriculture and infrastructure to human health and economic development (IPCC 2014). The diversity and localization of climate impacts suggest a critical role for local government organizations and state agencies, however, climate change policy and activities varies widely across subnational governments. This is especially true for adaptation efforts, where effective action can potentially occur with lower coordination costs than are required for mitigation policy.

There is wide recognition of the critical role of subnational governments at both the international and domestic policy levels. Following the entry into force of the Paris Climate Agreement and the COP22 meeting in Morocco, the Marrakech Roadmap for Action was signed by representatives of 114 local and regional leaders calling for a more explicit emphasis on local financing for climate policies and promoting "the role of local and regional governments as primary partners of the central States" (Marrakech Roadmap for Action, 2016). In 2018 the CitiesIPCC and Climate Change Science Conference was organized explicitly around establishing the next frontier of research to be focused on cities and climate change (CitiesIPCC, 2019). Domestically, cities and local governments were identified early as a way for the Obama administration to by-pass congressional inaction and align federal agencies with state and local risk-mitigation and other adaptation efforts. Executive Order 13653 updated the 2014 Federal Emergency Management Agency (FEMA) guidelines for state, tribal and local hazard plans as a means of bringing

federal resources to state and local jurisdictions. It obligated them to at least "consider climate variability as part of their requirement to address the probability of future events in state planning efforts" (Executive Order 13653, 2013). One of the stated intentions for EO 13653 was to allow for "for more resilient and sustainable recovery" with actions to include "elevating or relocating homes and businesses to reduce flood risks associated with sea-level rise and more intense storms or rebuilding to higher standards" (Executive Order 13653, 2013). The order was rescinded March 28, 2017 by President Trump. Planning activities at the state level in the form of climate vulnerability assessments, adaptation plans, and mitigation efforts continue, although they have significantly slowed (Wheeler 2008).

In spite of significant activity and attention from the research community on subnational climate action, there is little empirical work testing many of the theoretical assumptions proposed. The empirical work that has been conducted is often case study based or focused principally on formal subnational organizations, and often lacks a theoretical perspective. This work represents an attempt to expand analysis into informal cooperative networks as well, examine how various forms of subnational self-organization around climate issues have influenced action on the ground, and test some of the theoretical assumptions embedded in polycentric approaches.

Subnational Climate Policy and Polycentricity

The first government action of any kind on climate was that of the City of Portland's 1993 GHG mitigation plan. This early action by cities led scholars to investigate which subnational governments were engaging in what was essentially framed as a global policy issue. Groundbreaking work of Bulkeley (2000) looked at which Australian cities were developing climate action plans. Betsill (2001) followed with an examination of GHG policies among cities who were members of the US Mayor's Climate Protection network. Subsequent work by Romsdahl and Wood (Romsdahl, et al. 2013; Wood, et al. 2014) has looked at natural resource and land use planning activities by local officials across twelve states in the Great Plains communities. A survey of cities globally examined members of the Local Governments for Sustainability (ICLEI) network to understand the motive of urban leaders to engage in local climate policy (Aylett 2014).

Similar work has been conducted among local governments in Britain (Porter et al. 2015) and India (Jogesh and Dubash 2015).

The climate policy scholarship has recently shifted from a distinct division between national, state and local action to a broader focus on multi-scaled governance (Bodansky et al. 2014, Gupta 2007, Jordan and Huitema 2014). Jogesh and Dubash (2015), in their study of interactions across local and national government adaptation planning, suggest that state-led efforts restrict local innovations as they seek to follow a central mandate. In an examination of local government motives for engaging international policy forums, Happaerts (2015) suggests that local governments cannot act as innovators due to the political ramifications driving cross-scale cooperation on climate toward the status quo. Alternatively, Hughes (2015) suggests that higher-level institutional support structures at state and region are critical for supporting local city action. While some efforts are driven internally (often associated with Mayor's initiatives), an external support framework is needed to navigate the complex vertical and horizontal relationships around policy action.

Subnational governments have a critical role in producing many of the public goods and services impacted by climate change (Rabe 2006, Victor et al. 2005) and act as the action arenas where state and national policy gets implemented (Oakerson 1999, Ostrom, 2010). However, much of the research on subnational climate policy has focused primarily on the activities of urban centers and membership in formal urban policy networks such as the Local Governments for Sustainability (ICLEI) and 100 Resilient Cities. While this work has been important in highlighting early climate policy activities and understanding the dynamic of local climate policy, it has tended to ignore activities in less prestigious arenas of cooperation such as suburban and rural communities, state agency-level activities, and smaller regional climate efforts between local and state governments. By focusing on high profile cases, lower level activities that may have greater trust, speak more to local concerns, have higher levels of interagency cooperation, and lead to actual implementation have been overlooked.

There are a number of theoretical reasons why lower levels of government may be more responsive to some climate issues. Responses by subnational governments are likely greater when the

impacts directly affect local constituents (Elazar 1995, Kauneckis and Andersson 2009, Ostrom 1994). Impacts such as droughts, wildfire, sea level rise, and infrastructure damage increases the risk dramatically for some regions. This creates incentives to act to reduce the risk through adaptation activities, regardless of actions at higher levels of governance. Free-rider problems still remain, and some jurisdictions have begun to form regional collaboratives to better coordinate actions. Examples include the San Francisco Bay Regional Coastal Hazards Adaptation Resiliency Group (CHARG) composed principally of local flood water management agencies and the Western Adaptation Alliance consisting of local government agencies in the southwest and intermountain region working together to address regional climate impacts.

Just as local jurisdictions have dissimilar exposure to risk, their capacity to respond is also highly differentiated. While more risk adverse locations may be willing to expend resources toward risk reduction efforts, others may choose to bear that risk. The link between citizen preferences and localized risk may partially explain differential responses across jurisdictions. Recognizing heterogeneity in the preferences of local constituents has policy implications for both mitigation and adaptation policy. Reducing greenhouse gas emissions is a collective action problem around a global atmospheric commons and local jurisdictions that limit emissions face immediate economic costs with little impact to the underlying problem. However, local preferences can serve to incentive policy action. Local mitigation can occur in spite of costs if the citizens of a jurisdiction have political preferences that support climate policies. Similarly, adaptation action can reflect a mix of preferences on bearing the cost to avoid harm, how likely that harm will occur in the future, tradeoffs with other policy priorities, and political narratives around the cause of negative impacts. Polycentric governance systems increase the number of decision points and can allow for greater experimentation and policy entrepreneurship (Mintrom 1997). As lower level governments work to solve local issues and cater to citizen preferences, they have the potential to become hubs of innovation where other jurisdictions can learn from local successes and failures across a wide range of local conditions.

The literature on emerging subnational climate governance has important implications for understanding local climate policy dynamics and offers a number of challenges to current research (Termeer et al. 2011). One of the principal critiques of much of the current literature is directed toward the methodology of case selection. The majority of work has focused exclusively on cities. While urban areas are centers of economic and human capital, and are more likely to have political constituencies more favorable to climate action, there are no inherent reasons why suburban or rural jurisdictions should be excluded from analysis. Especially in term so adaptation policies, since rural areas face the immediate direct impacts from changing ecological systems, have higher exposure to some types of risks such as wildlife, and many of the effect directly impact rural economies such as agriculture and forestry. The urban focus, having both more resources and different political constituencies, have likely biased our understanding of the process of climate policy formation. Focusing on urban areas also over-represents those climate activities intended to reduce risk to urban environments (ex: infrastructure, heatwaves, flooding) and underrepresents activities more associated with suburban and rural communities (ex: forest management, crop selection, zoning). In particular, the quantitative analysis that have been done that reply on sampling within formal climate membership-based organizations select those already active in climate discussions not allowing for any comparison with subnational jurisdictions not involved in that particular network, nor those who may be taking autonomous action. This makes it difficult to answer the underlying question of what conditions are necessary to foster subnational climate policy activity.

Other issues arise from lumping together mitigation with adaption actions which likely involve very different policy processes. Additionally, member does not mean either active network participation nor implementation (Dupuis & Biesbroek, 2013). Using high profile formal members as a measure of climate change activity over-counts real action, overstates the actual commitment of jurisdictions to implement policy, and misses the types of informal interactions that while less politically symbolic can lead to real action. In fact, two of the largest urban climate networks, the Mayor's Climate Protection Agreement and ICLEI only require voluntary commitments to a list of guidelines. There are no associated

sanctions for unfulfilled commitments, no monitoring of compliance, and membership is neither lost nor denied at any stage.

The analysis presented here attempts to address those gaps in the current research. Methodologically it represents the first national survey of subnational government organizations that had the potential to be engaged in climate change activities. There were no criteria based on population, urban/rural divisions, or constraint on the specific type of activity constraints (infrastructure, drought, flooding, etc.). Similarly, there was no formal membership criteria for the sample selection, avoiding the aforementioned problem of selection on those already engaged in climate discussions. Cooperation in climate networks was open to information seeking activities, partnership building, mitigation, adaptation or any other potential climate activity. Specific actions and sectors were coded to differentiate types of adaptation activities and sectors. Secondary data was utilized in order to understand how structural factors may impede or support subnational climate adaption action, cooperation across jurisdictions, and local political effects.

Methods

The study uses the Local Climate Policy Project (LCPP) data, a survey of subnational government agencies. The survey instrument focuses on the types of public sector activities the organization was responsible for delivering, whether there are climate planning and policy activities, the importance of climate change to the organizational mission, level of engagement in climate policy networks, among others. The survey was sent to organizations selected from the 2013 *Leadership State-Muni Premium* online database. From among the 53,000 state officials, legislators, local officials and public agencies listed, 11,751 organizations associated with public services that could potentially be impacted by climate change were selected. Since the study was the first national-scale survey, participation invitations were sent to an extremely broad array of organizations. Many of which were unlikely to have climate change related activities, however the researcher wanted to avoid preconceptions about which organizations might be engaging on climate policies. As an exploratory effort, this broad sampling strategy allowed capturing

small activities, a wider range of actions, as well as jurisdictions and organizations not often associated with climate policy. The tradeoff was in the response rate. Invitations were sent via email in three waves, with a fourth mailed as a paper survey mail to ensure responses from those with less internet connectivity. The total number of respondents included 1,233 replies to the online survey, and 103 responses to the mail survey, for an overall response rate of 11.4%.[1] Responses were received from all 50 states, the District of Columbia, and the overseas territories of American Samoa, Guam and Puerto Rico.[2]

Because of the nature of policy responsibilities in the US, with shared and often overlapping responsibilities across different public organizations, public/private partnerships, and the exploratory nature of this research, the types of organizations included was intentionally kept broad. Four types of subnational governments are included in this analysis: local government agencies (61.02% of respondents), state government agencies (31.24%), special purpose units (5.22%), and regional agencies (2.51%). All responses were geo-located based on address and associated with county jurisdictions for secondary data collection. Climate activities were coded as anything undertaken by a subnational organization that was directly related to mitigation of GHGs or managing the potential impacts of climate change. The data used in this analysis concentrates on adaptation activities. These were coded to include a range of actions from increased monitoring activities, vulnerability assessments and planning, to implementation of new programs and/or policy changes.

[1]The population selected for the survey was intentionally extremely diverse in order to gather information from as wide of a variety of local government organizations as possible. Organizations were selected to include any that potentially had activities related to climate change. While the diversity of organizations included resulted in a lower response rate than studies focused specifically on those sectors directly impacted by climate (water for example), it allows for a fuller picture of climate related activities and those engaged in a broader diversity of network types.

[2] The maximum response rate as a proportion of those organizations invited to participate was from Nevada (30%) and minimum was from Vermont (3%). The large response rate for the State of Nevada was likely due to the University of Nevada being on the return address. No apparent reason was available for the small response rate from Vermont. In terms of potential biasing of the data due to a higher proportional response rate from Nevada, it accounts for only 2.4% of all responses examined here. Overall, each state's contribution to the data averaged approximately 1.8%, with a median score of 1.3%. The largest contribution from any state was that of California (13.5%) followed by Florida (6.2%) and Texas (5.8%) reflecting the relative size of each states population and government.

Respondents were asked to provide information about their management responsibilities, whether they were engaged in any climate policy activities, and other organization and group with whom they meet and collaborated with around climate issues. The measure of network membership used in this analysis was participation in any type of climate change meeting activity as reported by the respondent. Meeting participation represent a willingness to engage on climate issues, active information seeking, and openness to establishing partnerships with other subnational governments, science-producing organizations such as universities and federal agency climate hubs, and regional peer local-to-local organizational networks. Survey respondents reported a wide diversity of meeting activities around climate change and partnerships with other subnational organization, state and national organizations, international, and even foreign subnational governments.

The dependent variable used across all models is whether a subnational organization reported any climate adaptation activity. This was self-reported by survey respondent and coded according to whether the activity was a direct or indirect response to changing climatic conditions by the research team. Even small rural local subnational agencies in political conservative regions that see the direct impacts of climate change on immediate concerns such as increased precipitation and flooding can implement storm water infrastructure upgrades that account for a wetter future based on climate scenario outputs while avoiding the politically charged discussion around climate change. The survey was designed to capture these small-scale adaptation activities that might be direct responses to climate impacts that are otherwise missed by high profile debates at the national and international levels. Open-ended text responses asking about any climate change activities were coded and cross-checked by two separate coders to indicate what activities represented adaptation. Examples of activities ranged from developing local climate vulnerability assessments, to changing land use regulations, to storm drain requirements to account for heavier precipitation patterns and flooding. Activities were classified according to four types of activities: monitoring, assessments, planning, and implementation. For the purpose of this analysis, all four were collapsed into a binary indicator of adaptation action.

The independent variables used follow four general theoretical characterizations of subnational engagement on climate change. Descriptive statistics for all variables are reported in Table 1. The variables included aspects well represented in the research literature (such as population density and partisanship) as well as new data collected for this project; such as network membership and the scale of activities in which partners are engaged.

Model 1 provides a simple combination of demographics, partisanship, climate risk, and state-level climate planning effort. Densely populated urban centers have lead climate policy innovation and there are numerous reasons to expect higher occurrences of climate action due to concentrations of wealth, human capital, organization capacity, and greater density and connectivity among subnational governments (Hawkins, et. al. 2015). The logged county level population of the location of a respondent was used as a continuous measure of urbanity. Population was logged in order to allow comparisons of small rural jurisdictions with large urban centers.

Climate change has become an increasingly partisan issue similar to abortion and gun control. While many of the vulnerabilities associated with climate impacts fall disproportionally on conservative rural counties, liberal and urban jurisdictions have taken up leadership on the issue, even if sometimes as merely a symbolic political statement. However, climate activities are expected to occur more frequently in politically supportive environments. The measure of local partisanship used here was the percent democratic votes in the 2012 Presidential election at the county level.

Climate risk was measured using the most directly observable indicator - potential flooding from sea level rise. Other measures of risk exposure, such as drought frequency, extreme weather events, and wildfire severity are more complex processes that involve dynamic interactions of natural systems with built environments and development patterns, as well as being less frequently observed events. Sea level rise represents a gradual, directly observable phenomena with few alternative explanations. The impact of sea level rise is the most direct and obvious effects of climate change and can cause flooding not only in areas adjacent to coasts, but also far inland via waterways such as deltas, impact groundwater supplies, change the range of coastal vegetation such as mangroves, and have infrastructure impacts along a distant

supply chain. Data on projections of flooding from future sea level rise models were obtained from NOAA (2016) and originally developed to produce a nationally consistent data sets from a variety of sea level rise models. A measure of the percept of land area inundated at the county level in one to six foot sea level rise increments was generated. Alternative measures of sea level rise were also used in various specifications of the model, but not reported here, including six separate continuous measures of the percent of a county inundated by increments of one to six feet of sea level rise, and a separate specification using the greatest overall percent of flooding in a county across all possible foot sea level rise scenarios. Since no substantive different impacts to any of the models occurred from the inclusion of the different measures, a simple binary variable is used in this analysis to represent whether a county faces any inundation from sea level rise.

A number of states have created both climate mitigation and adaption plans and have offered various levels of support for state agencies and local government (Engel & Orbach, 2008; Kresge Foundation, 2017). The ability for local government, or even state agencies, in some situations to act independently of state legislatures and executives has led to a more dynamic view of local, state, federal relationships than that of the simple Dillon's v. Home Rule dichotomy (Carlson, 2003; O'Leary, 2020; Parlow, 2007). It is reasonable to assume that more supportive state governments should lead to higher levels of subnational government climate activities. The most heavily researched area has been on State Climate Plans (Peterson, 2004; Wheeler, 2008) which is used as a proxy for overall state climate engagement. Since each state has from zero to multiple plans, ranging from climate vulnerability assessments to mitigation, and that vary in size, the intensity of state climate planning effort was measured using the total number of pages across all types of climate plans.

The second model examines the relative impact of a subnational government's engagement in either a formal or informal climate policy network. This research is interested in informal interactions as well formal memberships, so network participation was collected by asking respondents whether they

participated in any meetings on climate issues. Respondents were then asked to name other organizations active in those meetings[3].

All network member named by respondents, were then coded in terms of what specific sector they represented and the scale of the responsibility of the network partner. Twenty-eight different sectors were found, ranging from transportation to public health and forestry. The most frequent sector reported were specialized climate organizations (25%), followed by those focused on sustainability (13%), planning (7%), and water (7%). The multi-sectoral nature of climate impacts has led some authors to suggest the importance of including multiple sectors in climate adaptation planning and implementation in order to fully address potential cross-sector impacts (Mimura et al., 2015). Model 2 utilizes the total number of sectors represented in a respondent's network as a measure of sectoral diversity.

Model 3 looks at the fundamental spatial characteristic of partners within a respondent's networks. Climate policy requires new coordinating structures to overcome the mismatch between the geographic and sectoral responsibilities of governments and the broad multi-sectoral impacts of climate change (Knopman & Lempert, n.d.). Collaborative networks have been discussed as a governance mechanism that can potentially bridge sectorial, spatial, and jurisdictional boundaries. In order to examine this empirically, the scale of responsibility for each partner within a respondent's networks was coded according to a nested federalism perspective of four categories: local (defined as within a single county, typically city governments), county, state, and federal.[4]

A number of authors have suggested that regional efforts may be more effective (Bodansky, Hoedl, Metcalf, & Stavins, 2014; Hegger, Van Zeijl-Rozema, & Dieperink, 2014; Termeer et al., 2011). Model 4

[3] As a data collection methodology the approach has a number of strengths and weakness. By having respondents give their primary networks around climate issues and naming partners by memory, it likely self-selects for the most salient partners, allows for informal network partners, emphasizes which partners are engaged with the most, and selects for those sources of useful information and exchange. Is does however mean that the number, type, and diversity of partners within a network is under-represented in this dataset, and that "weak links" (Granovetter, 1973) are under-represented as well as the overall structure being represented as much less connected and diffuse.

[4] These accounted for local (10.3%), County (9.8%), State (24.3%), and National (17.9%). Two categories of partners spatial responsibilities were not include in this analysis Universities (5.4%), which were understood to have activities that were aspatial, and international (9.4%). The other categories were those that involved regional collaborations.

tests this assumption by including the spatial characteristics of partners whose responsibilities span cross jurisdictional and spatial boundaries. Three additional categories of network partner's regional extent were included: partners whose activities linked counties across states (county interstate), those that linked counties within a single state (county intrastate), and those that linked states in a regional collaborations.[5]

Results

The four model specifications were run to account for the differential influence of each set of variables. Full results are presented for each model specification in Table 2. The first model examines the characteristics of a community as the key factors influencing the probability a respondent has engaged in a climate adaptation action. Of the four variables examined (population, democratic vote, threat of sea level rise, and intensity of state climate planning efforts) three were statistically significant at the 0.05 level or below. The greatest impact was from the percent democratic vote (coeff. 1.93, $p<0.001$), followed by potential flooding from sea level rise (coeff. 0.29, $p<0.05$) and state climate planning (coeff. 0.00, $p<0.01$). It is important to note the miniscule coefficient associated with state climate planning efforts.

The second model specification tests the impact of network membership and the diversity of sectors represented within the network, along with the control variables examined in model one. Both percent democratic vote and seal level rise remain statistically significant, while state climate planning does not. Network membership however is not only significant, but now provides the largest coefficient of any variable tested so far (coeff. 2.92, $p<0.001$). The diversity of sectors within the network has no discernable effect. The third model add variables representing the scale of network partners at the local, county, state and national level. There are two important effects. First, none of the control variables from the first model remain significant, while network membership retains its importance and the size of the coefficient alters only slightly (coeff. 2.79, $p<0.001$). Having a network partner at any of the four scales had no impact on climate adaptation actions.

[5] The frequency of regional networks were county interstate (2.3%), county intrastate (10.5%), and state-to-state (8.2%).

Model 4 represents the fully specified model. Among the initial control variables, only state climate planning remains significant, however the coefficient size is negligible (coeff. 0.00, $p<0.05$). Network membership remains the most important factor associated with adaptation (coeff. 3.07, $p<0.001$). Importantly, having a network partner who is engaged in state-to-state cooperation is both significant and has a substantial coefficient (2.12, $p<0.05$). Model fit statistics, including McKelvey & Zavoina's R_2, are as good as or better than model specifications 2 and 3.

Discussion

As subnational governments begin to tackle the impacts of climate change to their local communities through a variety of adaptation measures it is increasing important to understand what types of governing arrangements facilitate action. The level of activity among states, county and municipal governments in forming collaborative and regional forums suggests the urgency around which they are taking the threat of climate change seriously. Polycentricity offers a framework for conceptualizing these emerging complex multiscale governance arrangements, while network analysis provides the structure of interactions and can disaggregate that complexity into more manageable analytic units. This analysis attempts to make the next step in testing assumptions of the influence that different aspects of polycentric systems have on generating productive outputs.

The analysis re suggests a number of important patterns. At no point is there evident that climate adaptation activities are confined to densely populated urban areas. While media attention and many of the largest-scale activities are in urban centers such as natural disaster recovery efforts along the Eastern and Gulf Coasts and king tide flood infrastructure in Miami, adaptation actions are occurring in smaller communities as well. Activity was recorded in counties with populations as small as 7,800 and a fully fifty percent of all activities were in counties with less than 430,000 in population.

While the partisanship around climate change has increased over the past decade, democratic vote as a predictor of climate adaptation activity is only significant in Models 1 and 2, with the effects reduced by network membership, state climate planning activities, and inter-state collaboration. This suggests that

subnational agencies when faced with political headwinds against climate adaptation find other avenues for support by engaging in multi-state networks and likely focusing on sector-based efforts rather than more comprehensive policies.

Both political partisanship and the connectivity of a subnational government agency to a climate policy network overwhelm the influence of objective climate risk. The threat of sea level rise and the impact of partisanship are only significant in the first two specifications, however the coefficients are some of the smallest, second only to the minuscule impact of state climate planning efforts. While sea level rise is only the most directly observable threat, most of the literature continues to suggest that the policy process dominates any objective measure of climate risk. Communities are responding to risks, but framed through political narratives and local policy processes.

The theoretical literature offers a mixed view of how state planning efforts impact local climate policy. While most assume state efforts provide a supportive framework for local action, some researchers (Happaerts, 2015) suggests higher-level planning efforts can constrain the local ability to act. The empirical evidence reflects the literature and potentially offers an explanation. While state efforts are statistically significant, their overall impact is too small to be meaningful. Subnational implementation agencies have alternative venue to engage on climate adaption efforts, and appear to be neither heavily hampered nor particularly empowered by state planning efforts. This will vary according to the specifics of each state, but overall planning effort has little direct influence.

In contrast to any of the measures of traditional hierarchical federalism (state-level planning, connections to the local, county, state or national scale), network membership provides the most robust and consistent predictor of climate adaptation effort. Across all model specifications it has the largest coefficient value and maintains consistent statistical significance. With both congress and the executive branches are actively antagonistic to climate change policy, there has been a flourishing of regional, state and local collaborations (Vella, Butler, Sipe, Chapin, & Murley, 2016). Even when there was a support structure through national agencies (USDA Regional Climate Hubs, NOAA Regional Integrative

Assessment (RISA)), regionalization was already the preferred approach under the Obama administration. Elements of that network has persisted, and seen the proliferation of sub-regional and voluntary associational networks. However in terms of providing a supporting framework for adaptation activities the most important interaction appear to be regional interstate networks. The most prominent in our sample included Western Adaptation Alliance, Great Lakes Integrated Science and Assessment (GLISA), and Department of Interior's Northwest Climate Science Center. Other notable regional cross-state collaborations include the Transportation and Climate Initiative of the Northeast, New England Interstate Water Pollution Control Commission, and the Heartland Sustainability Network.

Conclusions

Polycentricity provides a broad theoretical approach for beginning to examine the complexity of climate adaption policy and implementation. The types of collective action structures emerging appear to lie between the functional specificity and jurisdictional boundaries of states as centrally important, but being driven toward more policy-specific cooperative architecture (Hooghe & Marks, 2003). While network partners are increasingly more diverse, the ability to implement a climate adaptation action appears to rely on regional interstate cooperation. Given the highly localized sampling method used here, this result suggest coordination problems across jurisdictions in producing the types of public goods needed for adaptation efforts are the central social dilemma at the subnational level. Network theory may provide an avenue for examining how different cooperation problems are managed at regional scales required for climate adaptation.

In order to develop more robust theory and unpack the complexity of new and evolving polycentric systems more empirical work is needed. Especially in terms of climate policy, researchers should attempt to move past high profile, often politically symbolic action and focus on the characteristics of governance systems that allow for implementation and action on the ground. This will mean attention to the action arenas that area able to span multiscale governance. The challenge of designing effective

climate adaption regimes requires a focus on the complex interactions across climate impacts, collection action, and governance arrangements.

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Table 1: Description of Variables

Variable	Type	Mean/Median	Min	Max	Std. Dev.	Description
Dependent variable						
Climate Adaptation Activity	Binary	0.32	0	1	0.47	Subnational agency reported at least one climate adaptation activity.
Local and State Characteristics						
Population	Continuous	13.03	8.77	16.10	1.09	Logged population at county level, unlogged population ranged from minimum of 6,429 to maximum of 9,818,605.
Democratic Vote	Continuous	0.55	0.15	0.91	0.13	Percent democratic vote in 2012 Presidential Election.
Sea Level Rise	Binary	0.36	0	1	0.48	Whether a respondent's county is threatened by sea level rise based on 1-6 foot projections.
State Climate Plan	Continuous	284	0	1938	425	Climate change planning effort at the state level, measured in total number of pages across all state climate plans
Network Characteristics						
Network Member	Binary	0.24	0	1	0.43	Membership of a climate change related policy network
Network Sectors Diversity	Continuous	0.04	0	11	0.29	Number of different sectors represented within a respondent's network
Network Partners Scale of Activity						
Local Scale	Binary	0.00	0	1	0.06	Respondent has at least one network partner whose activities: are at a city, town, or otherwise below the spatial scale of a county
County Scale	Binary	0.00	0	1	0.06	… are contained within a county
State Scale	Binary	0.01	0	1	0.09	… are contained within a state
National Scale	Binary	0.01	0	1	0.08	… are at a national level
Interstate County-to-County	Binary	0.00	0	1	0.03	... involve county-to-county cooperation that cross state boundaries
Intrastate County-to-County	Binary	0.00	0	1	0.06	…activities involve county-to-county cooperation within a state
Regional State-to-State	Binary	0.00	0	1	0.05	…activities involve state-to-state cooperation

Table 2: Results across all Model Specifications

Dependent Variable **Climate Adaptation Activity**	Model 1 **Local Characteristics**		Model 2 **Network Member**		Model 3 **Network Characteristics**		Model 4 **Network Partners Scale of Activities**	
Independent Variables	Coeff.	Z-score	Coeff.	Z-score	Coeff.	Z-score	Coeff.	Z-score
Population	0.06	0.91	-0.02	0.27	-0.01	-0.09	-0.03	-0.29
Democratic Vote	1.93***	3.68	1.24**	1.71	1.30	1.78	1.26	1.73
Sea Level Rise	0.29*	0.15	0.67*	0.67	0.12	0.59	0.15	0.71
State Climate Plan	0.00**	2.46	0.00	1.91	0.00	1.92	0.00*	2.13
Network Member			2.92***	9.10	2.79***	8.65	3.07***	14.07
Sector Diversity			0.14	0.83				
Local Scale					-0.08	-0.18		
County Scale					0.15	0.50		
State Scale					0.78	0.41		
National Scale					0.29	0.41		
County Interstate							-0.68	-0.92
County Intrastate							-0.24	-0.54
State-to-State							2.12*	2.03
Constant	-2.68***	-3.34	-2.29*	-2.11	-2.51	1.10	-2.29	-2.09
	N = 1,200		N = 1,040		N = 1,040		N = 1,040	
	chi_2 (4*df*) = 53.26		chi_2 (6*df*) =385.89		chi_2 (9*df*) =389.98		chi_2 (8*df*) =393.43	
	Loglikelihood =0.000		Loglikelihood=0.000		Log likelihood =0.000		Log likelihood =0.000	
	Pseudo R_2 = 0.03		Pseudo R_2 =0.31		Pseudo R_2 =0.31		Pseudo R_2 =0.31	
* p < 0.05	AIC = 1.25		AIC =0.86		AIC =0.86		AIC =0.86	
** p <0.01	McKelvey		McKelvey &		McKelvey		McKelvey	
*** p<0.001	& Zavoina's R_2 = 0.57		Zavoina's R_2 = 0.38		& Zavoina's R_2 = 0.39		& Zavoina's R_2 = 0.40	