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Seawalls or social recovery? The role of policy networks and design in disaster recovery

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ABSTRACT

This mixed-methods study examines the case of 30 advisory committees across 25 municipalities in Miyagi and Iwate Prefectures in northeast Japan after the 3/11 triple disasters. Drawing on synthetic control experiments, social network analysis, and case studies, we test whether the design of these committees' policies or the traits of these committee networks improved the recovery trajectories of municipalities. We find that communities highly connected to this network of advisory committees saw better economic recovery than expected, especially when researchers, hyper-connected individuals, or plans for community centers were involved, controlling for disaster damage, infrastructure quality, social vulnerability, governance capacity, emergency services, and social capital. Our results bring with them a number of concrete policy recommendations for disaster managers, local residents, and decision makers.

1. Introduction

Soon after the 3/11 tsunami, earthquake, and nuclear crises hit Japan's northeastern Tohoku region in March 2011, many affected communities mobilized to create disaster reconstruction committees. These advisory boards generated a wide range of policy proposals that local, prefectural, and national governments could implement as their recovery roadmaps. Some committees shared experts, leading to knowledge sharing across horizontal and vertical levels of government, while others were isolated with few members in common. This paper seeks to understand why some communities recovered better than others and the degree to which advisory committees shaped these recovery outcomes.

This mixed-methods study examines 30 advisory committees across 25 municipalities in Miyagi and Iwate Prefectures in northeast Japan after the 3/11 triple disasters. This recovery process is still ongoing, and some long-term impacts of recovery strategies may take years to uncover. However, recent data on income and human migration between 2000 and 2017 allow us to benchmark the effects of disaster recovery committees and their policy recommendations in the first six years following the disaster in March 2011. Drawing on synthetic control experiments, social network analysis, and case studies, we test whether the design of committees' policies or the traits of committee networks improved the recovery trajectories of municipalities. We find that communities highly connected to this network of advisory committees saw better economic recovery than expected, especially when researchers, hyper-connected individuals, or plans for community centers were involved.

This study carries three major contributions for scholarship. First, our findings build on the works of policy network studies (Howlett, 2002; Garrett and Jansa, 2015; Desmarais et al., 2015; Collingwood et al., 2019; Scott, 2013; Angst and Hirschi, 2017; McGee and Jones, 2019). Policy networks refer to formal institutional and informal ties linking actors involved in policy making and implementation, including government actors but also private sector or civil society actors (Howlett, 2002; Rhodes et al., 2008). In this study, policy networks are represented by interconnected members of municipal disaster recovery committees, whose ties help shape strategies for recovery and policies eventually adopted by municipal officials. This study adds new evidence that policy networks shape policy outcomes in disaster recovery, in ways distinct from the bonding, bridging, and linking social networks more frequently discussed in the literature.

Second, our findings about the influence of researchers on recovery add to the literature on problem definition and policy communities (Farley et al., 2007; Rochefort and Cobb, 1994; Samuels, 2012; Stallings,

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1990). The presence of researchers - mostly engineers - did boost economic recovery, we find, but such experts tend to narrowly define recovery as a physical infrastructure problem. Defining the policy problem this way inclines communities to focus on building seawalls, which did not conclusively benefit recovery either way, but distracts from other recovery priorities, such as strengthening social infrastructure (Aldrich, 2019). As our case studies show, the choice to invest in community centers was strongly related to better economic outcomes over time, more so than the choice to invest in hard infrastructure.

2. Literature review

This study examines why some communities recover better than others and how the composition of recovery committees affect recovery outcomes. Past scholars have taken six main approaches to explaining recovery outcomes: pre-disaster conditions, including 1) *infrastructure preparedness*, 2) *social vulnerability*, 3) *public goods provision*, and 4) *social infrastructure / social capital*, and post-disaster interventions, including 5) *policy design* and 6) *policy networks*. We summarize the literature on each below.

2.1. Infrastructure

Some disaster scholarship highlights that communities' traits prior to disasters vastly shape their capacity to recover. Historically, policymakers, bureaucrats, and engineers have assumed that vulnerability to disaster depends on the quality of physical infrastructure and other technocratic criteria (Petit et al., 2013; Boin and McConnell, 2007). Communities that suffer greater deaths and damages during crisis will struggle to recover long-term, and so greater investment in infrastructure prior to crisis is key to improving recovery. This category may focus on the presence or absence of seawalls, for example, or hardened coastal infrastructure.

2.2. Social vulnerability

On the other hand, even with the right infrastructure preparedness, socially vulnerable communities might struggle to recover. Residents with traits of vulnerability, such as persons living in poverty, minority racial or ethnic groups, women, children or elders, and persons with disabilities, among others, might struggle to obtain assistance after crisis, due to discrimination or sheer amount of need (Cutter et al., 2003; Cutter et al., 2006). However, some socially vulnerable communities might recover better if local governments provide more of key public goods like quality funding for emergency services or social welfare assistance, or if community members can mobilize to provide mutual aid themselves.

2.3. Social capital

Past research shows that in communities with stronger social infrastructure and social capital, that is, the ties that facilitate collective action and information and resource exchange, residents are more likely to help their neighbors, vote, and petition local officials for desired policy changes after crisis (Putnam et al., 1993; Aldrich and Crook, 2007; Aldrich and Meyer, 2015). These social ties come in multiple forms. Bonding social ties connect members of the same social groups, such as family, neighbors, or ethnic groups (McPherson et al., 2001), while bridging ties connect members of different social groups, such as through parent-teacher organizations, religious organizations, sports leagues, or volunteer groups (Putnam, 2000; Aldrich, 2012; Andrew et al., 2015; Smiley et al., 2018). Finally, linking ties connect residents with local officials, and help them access public goods (Szreter and Woolcock, 2004; Tsai, 2007; Aldrich, 2019).

However, each school of thought discussed above focuses on communities' capacity *before* disaster. After accounting for differences in infrastructure, social vulnerability, public goods provision, and social capital, what interventions can communities adopt *post-disaster* to improve recovery? Below, we compare literature on two key interventions: *policy design* and *policy networks*.

2.4. Policy design

Public policy scholars highlight that governments may achieve different results not just due to implementation problems (Pressman and Wildavsky, 1973; Bardach, 1977; Lipsky, 1980), but because of the goals and tools that policymakers designed for implementing those policies (Bobrow and Dryzek, 1987; Howlett, 2019). Early policy design scholarship highlighted how governments could accomplish the same policy goals using direct or indirect governance, encapsulating subsidies, grants-in-aid, vouchers, loan guarantees, decentralization, regulation, quasi-public–private-corporations, and contracting out to private firms (Salamon, 1989). More recent scholars delineated these into four tools of governance, including informational resources, organizational resources, financial resources, and legal authority (Hood and Margetts, 2007).

Past scholars adopted a policy design approach to disasters, arguing that policies can be direct and *hard*, involving infrastructure, state funding, and little customization, or policies can be indirect and *soft*, focusing on community development (Aldrich, 2012, 2019; Edgington, 2010). While hard policies increase investment and employment in communities when they need it most, this financial boost is usually fleeting; meanwhile, soft policies maintain the social cohesion of communities. Past studies indicate that soft and hard policies are best implemented together to improve recovery (Fraser et al., 2020). We might expect that in communities where committees proposed and governments implemented hard policy designs, financial recovery improved at the expense of human recovery. Conversely, we might expect that communities that utilized soft policy designs saw greater community mobilization and cohesion over time.

2.5. Policy networks

Alternatively, scholars highlight that the policy approaches governments adopt are shaped by *policy networks*. While governments often adopt policies based on their own resources and motivations, roughly encapsulated by pre-disaster conditions discussed above, governments may learn or imitate policies from other jurisdictions, spreading via multiple mechanisms, such as geography, coercion from governmental or non-governmental organizations (Berry and Baybeck, 2005; Berry and Berry, 1990; Desmarais et al., 2015; Kammerer and Namhata, 2018; Shipan and Volden, 2008; Berry and Berry, 2018). While past studies primarily focused on whether a specific policy diffused throughout a system of jurisdictions, like the diffusion of conservative policies from the American Legislative Exchange Council to different US legislatures (Collingwood et al., 2019; Garrett and Jansa, 2015), multiple different policies could diffuse throughout a network of disaster recovery committees. As the exact process is difficult to observe, we hypothesize that communities more interconnected by these committees are more likely to adopt cutting edge recovery policies, while communities more isolated from these committees might see cookie-cutter recovery policies and outcomes. This was especially true because the Japanese government regularly promulgated standardized recovery plans after shocks (Cheek, 2020), pushing out the same guidance to all cities, towns, and villages regardless of local differences (Aldrich, 2012; Aldrich, 2019).

2.6. Hypotheses

In summary, this review finds two major hypotheses for how policy can shape post-disaster recovery, namely the effects of **(H1)** *policy design* versus **(H2)** *policy networks*. These aspects of policy might shape recovery even after accounting for pre-disaster conditions like

infrastructure preparedness and damage, social vulnerability, public goods provision, and communities' social resources. First, we hypothesize that *policy design* might determine recovery outcomes: **(H1)** Communities that adopt soft, community development policies might recover better than those which adopt hard, infrastructure policies. Second, we hypothesize that *policy networks* might determine recovery outcomes: **(H2)** Communities with strong, embedded policy networks might tend to implement creative policies following best-practices in disaster recovery research and peer communities. These policies might be creative, incorporating local and regional knowledge from members embedded in policy networks, and such policies might deviate from the standardized checklist of infrastructure-heavy disaster recovery strategies encouraged by the Japanese central government (Aldrich, 2019; Cheek, 2020). Meanwhile, communities isolated from policy networks may tend not to implement those policies, suffering worse disaster outcomes as a result. Policy design *and* policy networks might both shape recovery, but this study hypothesizes that policy networks play the foremost central role in shaping recovery policies' design and eventual recovery outcomes. We test these hypotheses using the research design outlined below.

3. Methods

This mixed methods study tests why some communities recovered better than others, and how advisory committees shaped these outcomes, drawing on descriptive statistics, social network measures, synthetic control experiments, and case studies to verify trends found. We focus on effects of municipal disaster committees on municipalities' recovery in terms of *policy networks* tying members together and the *policy tools* that these committees proposed.

Japanese municipalities frequently rely on topical advisory committees to develop and recommend policy social services, environmental affairs, and in this case, disaster recovery. Committee positions are typically voluntary, unelected, unpaid, have term lengths of at least 1 year, if any, and may include a committee chair (sometimes a retired public official). We analyze the full universe of known municipal recovery committees launched after the 2011 disaster in Japan, collected by (Fraser et al., 2021), based on lists of known committees compiled by Tohoku University's Institute for Disaster Reconstruction and Regeneration Research and prefectural government offices (Miyagi Prefecture, 2018; Iwate Prefecture, 2018; IDRRR, 2018).

Members are usually publicly recruited, but unelected. Members are chosen locally but some were chosen from beyond municipal borders, especially prominent researchers in the region or government officials. Some committees diversified representatives, by including members from different economic sectors, neighborhoods, temporary housing committees. Unlike political office, committee structure and by-laws vary widely from town to town. The main commonality is that all committees deliberated together to create a set of recommended recovery policies for local officials to implement, some of which were then adopted by officials. Japanese disaster committees included a mix of members, most commonly from local businesses, such as fisheries and agricultural cooperatives, experts from local universities, government officials or staffers, and citizens representing social organizations or nonprofits (Fraser et al., 2021). (For this reason, our analysis below considers differing levels of representation from these four sectors in policy networks.)

Committees usually met several times in early months after the disaster. Some committees stayed active for years while others closed down by 2012 as municipalities began implementing recovery policies. As a result, this study's design tests the effect of committees' networks and policies from *the year immediately following the disaster* on recovery *over subsequent years.* (Future studies and data collection could examine whether the *length of time that committees stayed active* affected recovery). Below, we introduce descriptive statistical tests, outcome variables and proxies for synthetic control experiments, and case study selection methods.

3.1. Describing disaster recovery committee policies

First, this study categorized the policies of each disaster recovery committee affiliated with a town by identifying policies proposed by a committee and which of those policies were also implemented by the town. We coded committees into hard policies or soft policies, outlined in Table 1. As an overall measure, we coded a committee as having proposed hard policies if a policy focused on physical infrastructure such as building seawalls, bridges, highways, or large infrastructure projects. In contrast, we coded a committee as having proposed soft policies if a policy focused on community development or social infrastructure, like community centers. Categories were not mutually exclusive; some towns were coded as adopting both hard policies and soft policies if they focused on both physical and social infrastructure; our models below also test this combined effect. However, most towns were strongly inclined towards one or the other.

We also coded several additional forms of soft policy, including whether they proposed 1) new public markets, 2) policies promoting community centers, 3) new public transit options (since enabling mobility is a key challenge for many rural, coastal Tohoku communities), and 4) publicly owned renewable energy systems, since enabling energy resilience is a community, preserving community ties.

These last two policies (public transit and public renewables) exemplify soft policies because they are strongly community-oriented and designed. For example, facing prohibitively high costs of rebuilding bridges, tracks, and stations for train lines, the community of Kesennuma worked with railway company JR East to restart public transit using Bus Rapid Transit (BRT) instead, helping residents resume contact to neighboring municipalities for work and family visits. Similarly, many communities like Higashi-Matsushima put publicly-owned photovoltaic systems atop community centers and other public facilities like hospitals as low-cost ways to ensure that key community sites are available for residents during the first 72 h of any future crisis. Others innovated with community-owned solar projects paying dividends to residents. These mark a striking difference from traditional hard infrastructure projects like roads, bridges, highways, and seawalls;

Table 1
Committee Policy Design and Policy Network Indicators.

Type	Concept	No.	Measure
Policy Design Toolkits	Hard Policy	1	Physical infrastructure focused policy
	Soft Policy	2	Community Development focused policy
	Hard & Soft Policy	3	Both Hard & Soft Policy
	Other Hard Policy	4	Building seawalls
	Other Soft Policy	5	Community centers
		6	Public market
		7	Public transit improvement
		8	Public renewable energy
Policy Networks	Representation	9	At least 5 members from Business
		10	At least 5 members from Social Orgs / NGOs
		11	At least 5 members from Government
		12	At least 5 members who are Researchers
	High Connectivity	13	High committee membership overlap (number of members sitting on multiple committees is greater than the median among towns with committees)
	Connectivity	14	Any degree of committee membership overlap
	Key Members	15	Member 1
		16	Member 59
		17	Member 68
		18	At least one of the top 3 most interconnected members

each are ways that Japan's Liberal Democratic Party historically provided public goods to political patrons (Scheiner, 2005). Finally, these are supplementary measures; publicly owned renewable energy systems and new public transit options always cooccurred with other measures of soft policy like community centers and public markets.

As a validity check, this study only tests effects of policies both proposed by a committee *and* implemented by the town. In the supplementary data file, we summarize and justify our coding for each community's policies. Together, these eight binary measures (numbers 1–8 in Table 1) contextualize the recovery policy approaches each town adopted based on the recommendations of disaster recovery advisory committees.

3.2. Describing committee policy network indicators

Next, we developed several indicators of committee policy networks in each town (measures 9–18 in Table 1). First, we measured what sectors were *represented* in committee policy networks (measures 9–12 in Table 1). We classified a sector as highly represented in that town's policy networks using a binary indicator (1/0) if that town hosted a committee with at least 5 members from businesses, from social organization or NGOs, from government, or from academia.

Second, we measured the connectivity of policy networks in each community. We calculated for each committee the total number of committee members overlapping with other committees, known as the *degree centrality* of that committee. Then, we added these together among any committees in a given town to get the total degree centrality of each town, representing the strength of that town's connectivity to other municipal level disaster committees in the disaster recovery committee network. Among towns with any overlap, the median degree was 16, representing 8 members held in common with other committees. Using this, we created two binary indicators of connectivity (measures 13–14 in Table 1): *high connectivity* refers to towns with a total degree of 16 or more, while sheer *connectivity* refers to towns with at least 2 degrees (meaning at least 1 member held in common with other committees).

Third, we measured the presence of three *key members* (measures 15–18 in Table 1), who are discussed at length in another publication (Fraser et al., 2021), including Member 1, an influential engineer, Member 59, a representative from East Japan Railway Company, and Member 68, a manager for the highway system. Their names have been removed to prevent them from being identified. We also measured the presence of *any of these three individuals* being involved in a town's recovery.

3.3. Linking commitee policy design and policy networks

Using the measures discussed above, we examined the relationship between disaster committee policies and committee traits. To do so, we conducted difference of proportions and difference of means tests on our sample of 25 towns hosting disaster recovery committees, using permutation tests to calculate statistical significance amidst our small sample size. We tested three relationships, described below.

First, we examined whether towns whose disaster committees had certain kinds of members adopted hard or soft policies more often, examining committees with at least 5 members from businesses, from social organization or NGOs, from government, or from academia. Since both of these outcomes are binary, we calculated what percentage more towns adopted hard policies, for example, if they had at least 5 committee members hailing from a specific sector.

Second, we examined whether towns were more likely to adopt hard or soft policies more often if those committees were *highly* or *moderately* connected to other disaster recovery committees. Third, we examined whether towns were more likely to adopt hard or soft policies if a key individual sat on a committee in that town. Finally, we test the effect of having any of these three individuals involved in a town's recovery on the likelihood that they adopt a specific kind of policy.

These tests highlight whether towns with certain levels of embeddedness in policy networks are more likely to favor one kind of policy design over another. Having identified the relationship between these policy indicators, next, we estimate their effects on recovery.

3.4. Synthetic control experiment

Next, we analyze the effect of 19 indicators of policy design and policy networks on recovery outcomes over time. We use two annual recovery outcomes, including income per capita in thousands of yen, signifying *economic recovery*, and net in-migration per 1000 residents, signifying *human recovery*. We hypothesize that communities which adopted specific interventions ((H1) "soft" policy designs and (H2) well-connected policy networks) saw greater improvement after 2011 in income per capita and net in-migration than did comparable towns.

To assess this, we use synthetic control experiments. When only a few towns adopted a policy, and this policy was not administered randomly, it can be challenging to identify how that policy affected the outcome. Synthetic control experiments build a synthetic control group from a set of municipalities that did not receive the treatment, weighted to match the treatment group in terms of several desired demographic traits. This study applies generalized synthetic control experiments to find the average treatment effect of an intervention over time (Xu, 2017). Synthetic control experiments are frequently used to study effects of rare interventions, such as tobacco policies, nuclear power plants, and more (Abadie et al., 2010; Ando, 2015; Abadie et al., 2015).

We applied synthetic control experiments to a dataset of 3024 municipality-years, drawing from all 168 municipalities in Japan from 2000 to 2017. We produced 38 experiments for 19 different treatment variables (highlighted in Table 1), one for each treatment's effect on our two outcomes, while using a series of weighting covariates to control for other effects. At times, for readability, we flip net in-migration to net out-migration; these are equivalent concepts.

We used the following proxies, outlined in Appendix Table A1, to construct a synthetic control group as similar as possible in terms of pre-disaster conditions to the towns which experienced the intervention. To control for infrastructure preparedness, we use the annual amount of municipal spending on public works per capita. To control for public goods provision, we use municipal spending on social welfare per capita and fire departments per capita (representing emergency services), as well as the town's financial strength index to measure overall institutional capacity.

To control for social vulnerability, we used (Fraser, 2021) index based on the method of Cutter and colleagues' US social vulnerability index (SoVI) (2003), which incorporates vulnerability by gender, racial and ethnic minorities, age, employment, and more, all important indicators of vulnerability in Japan, like other advanced industrialized democracies. Cutter and colleagues' index has been adapted to measure social vulnerability in countries around the world, including Japan (Fraser, 2021), Brazil (de Loyola Hummell, Beatriz Maria, Cutter, S.L. Emrich, C.T., 2016), Portugal (de Oliviera Mendes, 2009), Italy (Frigerio et al., 2018), Nepal (Aksha et al., 2018), and Bangladesh (Rabby et al., 2019), among others. The Japanese index showed strong internal and external validity, correctly predicting known correlates among coastal Tohoku communities after the 2011 earthquake (Fraser, 2021). To supplement this, we measured income per capita in thousands of yen (except for when it was used as an outcome variable), as well as the unemployment rate per thousand persons, the percentage of secondary sector employment, and the share of the population who are women and ages 65 or above to reflect age.

To control for social capital, we used new bonding, bridging, and linking social capital indices, adapted from (Kyne and Aldrich, 2020) county level Social Capital Index (SoCI). The bonding index captures homophily in terms of nationality, religion, income, employment, employment by gender, age, and communication capacity. The bridging

index captures inter-group ties through unions, religious organizations, volunteer participation, and voter turnout, while the linking index captures connectedness to local officials through rates of municipal employees, police, and elected officials per capita, supplemented by support for the winning party in recent elections. We also controlled for total migration, the share of residents that came to *or* left town annually, to represent overall social cohesion.

Finally, to control for disaster effects, we used the number of deaths per municipality and the number of buildings damaged in the crisis. Our synthetic control models used these covariates to weight cases and identify the most appropriate cities for comparison to test the effect of policy design and policy networks on recovery.

3.5. Case selection

Finally, to verify our results, we conducted short case studies of two Tohoku municipalities struck by the disaster: Ishinomaki City and Onagawa Town. These cases were not most-similar cases; Ishinomaki is a city of 141,700 residents, while neighboring Onagawa hosts just over 6,300 residents. Instead, we chose these as two distinct cases selected by (Lieberman, 2005) strategy of *nested analysis*. This investigates results of Large-N analyses by selecting an emblematic, "on-the-line" case demonstrating the trend predicted by our models, paired with a divergent, "off-the-line" case demonstrating a different trend poorly explained by the models. As discussed below, this study finds strong evidence that **(H2)** policy network traits shaped recovery, aided by **(H1)** soft policies focusing on community centers. We draw on Ishinomaki City as our emblematic case, to demonstrate *how* policy networks and soft policies promoted stronger economic improvement. As our divergent case, we examine Onagawa Town, to investigate why it saw weak mixed recovery trajectories *despite* high connectivity with policy networks and soft policies. These case studies contextualize how policy networks and policy design interact to shape recovery outcomes.

4. Results

This study investigated which interventions improve recovery trajectories most, using synthetic control experiments and case studies. We hypothesized that **(H1)** soft, community-development focused *policy design* improve recovery, and that **(H2)** well-connected *policy networks* also lead to better recovery outcomes. First, we describe the relationship between policy networks and policy design. Second, we test our hypothesized effects of **(H1)** policy design and **(H2)** policy networks on recovery by modeling the difference in outcome for towns that received the intervention and comparable towns that did not. We compare the effects of policy toolkits, policy networks, key members of policy networks, and representation in policy networks. Finally, we discuss the municipalities of Ishinomaki and Onagawa.

4.1. Describing committee policy design and policy networks

First, we analyzed to what degree policy networks shape the policy toolkit that towns adopt. Fig. 1 displays the results of 72 bivariate differences of proportions tests, indicating by color any strong positive associations (blue) and negative associations (orange). For example, the upper-left most cell shows that towns where Member 1 serve on a committee were

12% less likely to adopt hard policies than towns lacking that member. This analysis highlights several relationships. First, towns where Member 1 was involved tended not to adopt hard policy tools, but they also tended not to adopt several soft policy tools. Second, towns where Members 59 and 68 were involved tended to adopt hard policy tools, such as building seawalls, but also *community centers*, a key soft policy. In fact, towns with any of these top 3 members tended to adopt hard, soft, or hard *and* soft policies together, indicating that these three members helped circulate both kinds of ideas.

Third, committee member traits had divergent relationships with towns' policy design. Towns with significant representation from businesses and government tended slightly to adopt hard policies. In contrast, towns with greater representation from researchers and

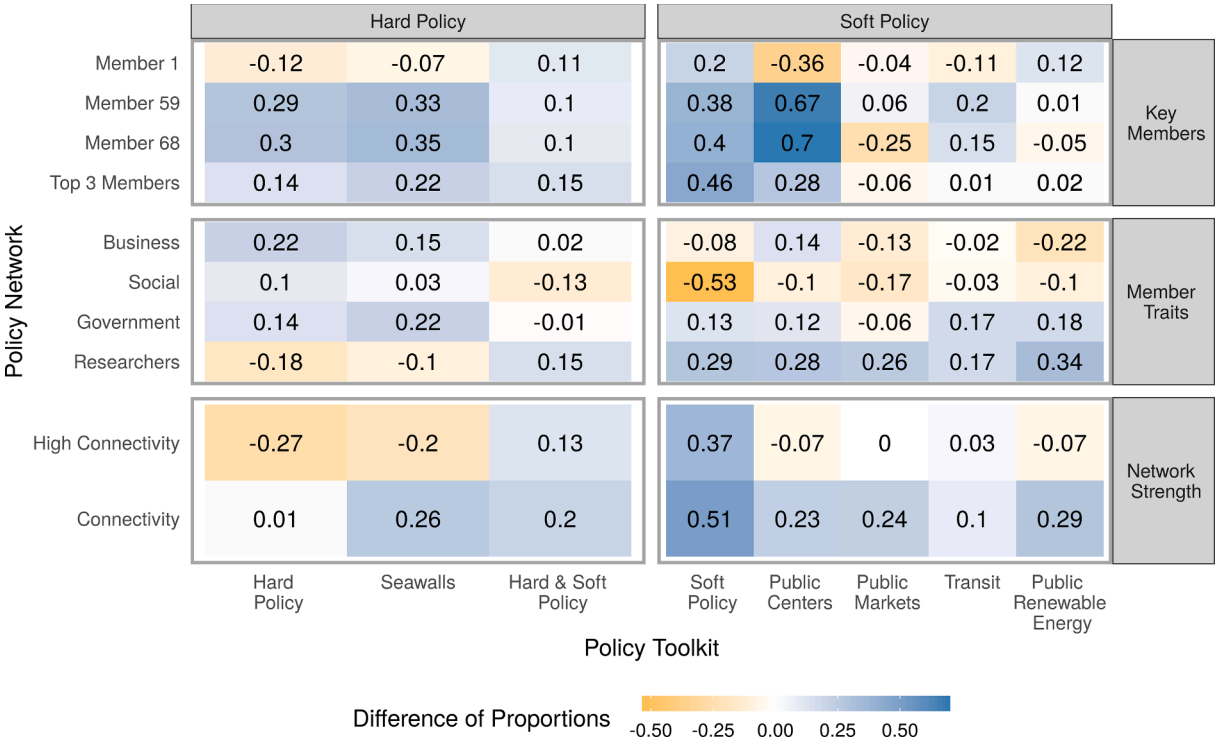

Fig. 1. Difference of proportions between policy toolkit & policy network traits.

government tended to adopt soft policies. On the other hand, towns with strong membership from civil society tended not to adopt soft policy, but especially tended not to adopt hard policy. Towns strongly embedded in committee networks tended not to adopt hard policy, but tended to adopt both hard and soft policy together (such as Ishinomaki below). In contrast, towns that were somewhat embedded in committee networks tended especially to adopt *each* soft policy. This implies that better networked towns tended to receive either significant expertise from engineers or valuable alternative strategies for community development, and often *both*, connecting communities with ideas they may not have otherwise encountered. Perhaps access to these networks affects recovery more than a single policy design, as we discuss below. If any specific policy design matters, it might be soft policies to build community centers, which were adopted in 67 ~ 70% of towns where Members 59 and 68 were involved. This marks important context for our hypotheses that (**H1**) soft policy and (**H2**) well-connected policy networks benefit recovery.

4.2. Synthetic control experiments

Next, this study tests its two hypotheses by applying synthetic control experiments to test the average treatment effect of each policy design and policy network trait. The average treatment effects of these variables are summarized in Table 2. Results for covariates are summarized in Appendix Tables A2-A5. Our analysis finds limited support for the effect of specific policy toolkits, but stronger evidence that policy networks shaped recovery trajectories.

First, regarding policy toolkits, we hypothesized that **(H1)** soft policies improve recovery rates. We found that hard and soft policy toolkits had slight positive effects on both net in-migration rates and income per capita, but neither were statistically significant. Notably, towns that adopted community centers, a key form of soft policy, saw greater income per capita over time (117,595 yen, or 1100 USD), while towns that adopted publicly-owned renewable energy initiatives tended to leak population over time. These show mixed results for our hypothesized effect of soft policy design on recovery.

On the other hand, we hypothesized that **(H2)** well-connected policy networks improve recovery rates, and we found that policy networks *strongly* boost economic recovery. Towns where committees involved at least 5 researchers tended to have 270,940 yen (roughly 2,600 USD) per capita more than we project it would have otherwise ($p < 0.01$). Highly connected towns, which share at least 8 committee members with other committees, saw a 151,134 yen (roughly 1400 USD) per capita boost ($p < 0.05$). Towns with any of the top 3 most high interconnected members saw a 201,398 yen (1900 USD) per capita boost in economic recovery outcomes ($p < 0.05$). However, each of these increases in income per capita were matched by a projected decrease in human recovery, ranging from 4 to 16 outmigrants per 1000 residents, with varying degrees of statistical significance.

Table 2
Average treatment effects.

Term	Income per capita in 1000 s of yen	Net Migration Rate per 1000 residents
Hard Policy	52.143	4.315
Soft Policy	−3.011	−0.641
Hard & Soft Policy	761.079	127.782
Build Seawalls	59.553	4.312
Community Centers	**117.595***	**−6.65***
Public Markets	41.5	−19.351
Public Transit Improvement	115.997	**−47.092.**
Public Renewable Energy	10.65	**−17.366****
+5 Members from Business	−1.303	−2.982
+5 Members from Government	−9.281	−22.282
+5 Members from Social Orgs/NGOs	−13.55	−0.078
+5 Members who are Researchers	**270.94****	−4.393
High Connectivity	**151.134***	**−12.383***
Connectivity	167.698	11.114
Member 1	243.949	−16.072
Member 59	63.966	−1.213
Member 68	57.94	−1.856
At least one Top-3 Member	**201.398****	−16.544

Note: Statistically significant results are highlighted with *** at the $p < 0.001$ level, ** at $p < 0.01$, * at $p < 0.05$, and . at $p < 0.10$.

These trends can be seen in Fig. 2, which displays the observed average recovery trajectory as a solid line for towns with highly connected policy networks, at least one of the top three most interconnected committee members, with five or more researchers on their committee, or which implemented community centers after the crisis. This solid blue line is matched by a dashed yellow line, which shows the average outcome for counterfactual cases, representing the outcome we would expect had towns not adopted the intervention in question. The wide blue and yellow bands show that while each town demonstrated considerable variation in outcomes, the divergence between averages is quite steep.

Finally, in Figs. 3-4, we visualized the recovery outcomes of two specific communities, compared with their expected conditions had they not experienced one of four key treatments (the same treatments from Fig. 2). The economic recovery of these cities deviated the most on average from what they would have experienced without input from researchers. The difference here is stark. Ishinomaki, the second largest city in Miyagi Prefecture, saw much greater continuity in income per capita than we estimate they would have had with less than five researchers advocating for policy on their committees. Fig. 3 also estimates Ishinomaki saw better economic recovery on account of highly connected committees and one of the three most connected members. These demonstrate well the **(H2)** hypothesized benefit of well-connected policy networks for recovery. In contrast, the town of Onagawa did not fit the expected trend, just narrowly matching the expected economic conditions of a town with fewer researchers. Clearly, researchers did not have the same projected effect in Onagawa as they did in Ishinomaki, Sendai, or other communities. We explore these divisions further drawing on 2 case studies of Ishinomaki and Onagawa.

5. Ishinomaki City: An emblematic case

The case of Ishinomaki City demonstrates the upward effect that (H2) well-connected policy networks can have on economic recovery, a good example of our second hypothesis at work. Ishinomaki, a coastal city located in northeast Miyagi Prefecture, has a population of 141,700 (Ishinomaki City, 2020). Ordinarily, Ishinomaki should have experienced a major dip in income per capita, but instead, our models projected that due to four key treatment effects, it maintained pre-disaster levels of wealth, with a slight dip after the disaster. These key factors were both related to policy networks and policy design.

Five individuals served on Ishinomaki's recovery committee, all researchers at various universities in Miyagi Prefecture (Ishinomaki City, 2017). Among these five professors was Committee Member 1, an academic and civil engineer at a major disaster research institute in the region and a member of 11 other committees, making him directly connected to 165 other members (Fraser et al., 2021). 80% of these committee members were male, with backgrounds in engineering or economics. In contrast, this committee had zero representation from businesses, NGOs, or local government officials.

Given this committee's composition, it is unsurprising that its approaches were especially infrastructure-focused, including building major physical infrastructure projects such as new seawalls. Ishinomaki's hard policy approach resulted in large-scale infrastructure projects,

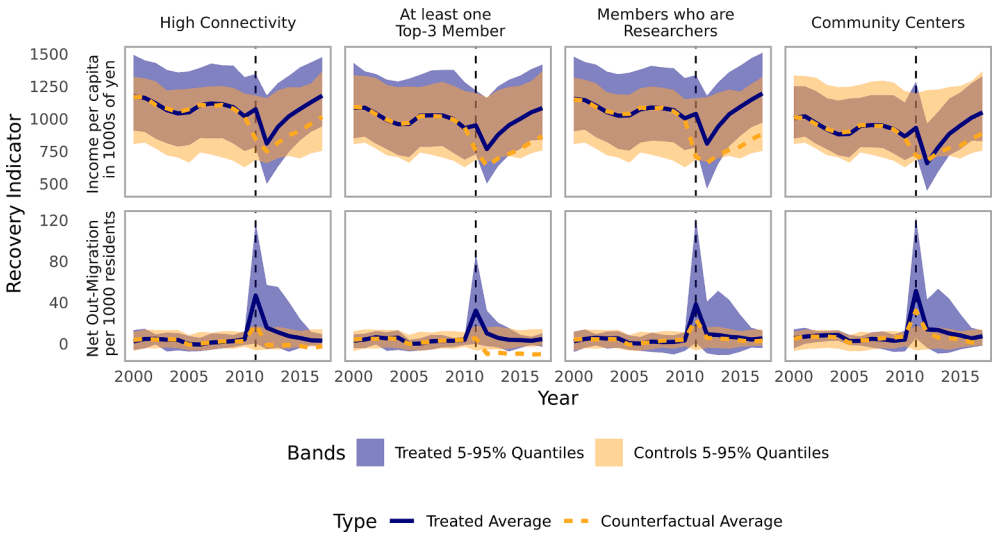

Fig. 2. Effects of policy networks on recovery.

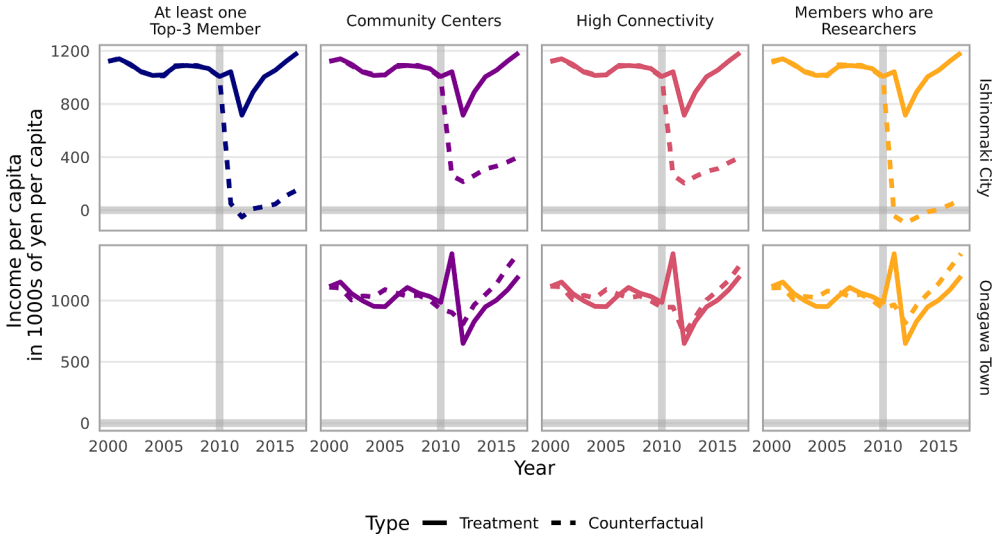

Fig. 3. Treatment effects on economic recovery.

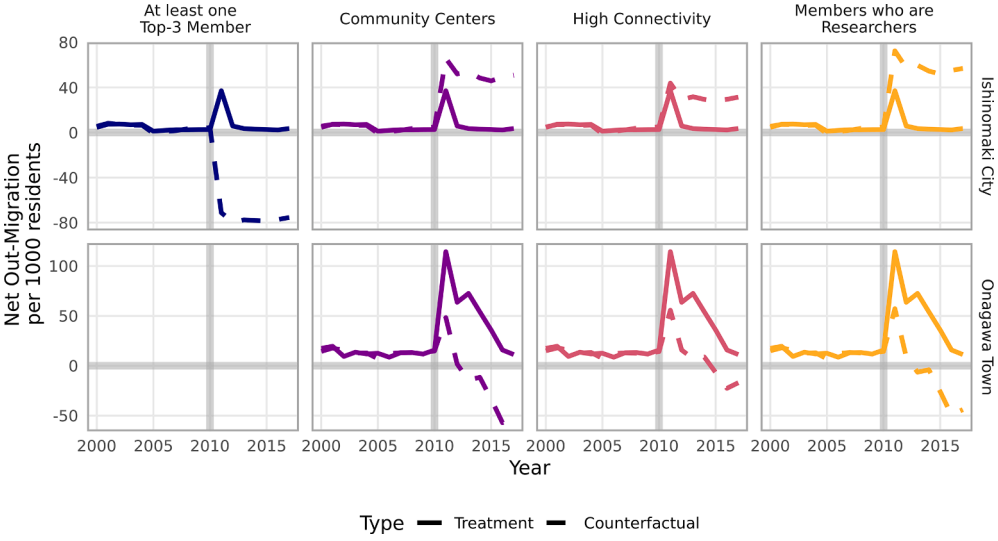

Fig. 4. Treatment effects on human recovery.

bringing money and construction workers to town. This was an important intervention for the local economy, generating a large construction boom, which was reflected in the city's income per capita staying mostly unchanged despite the disaster. However, the breakdown of civil society, a related problem expected to accompany hard policy approaches and construction booms, did not occur.

This is because Ishinomaki took mixed approaches to recovery, recommending both hard *and soft* policies. These included community development programs through establishing several multipurpose community centers and public meeting facilities (Ishinomaki City, 2013). For example, the Reconstruction Town Development Information Exchange Center in central Ishinomaki, constructed in 2015, serves a dual purpose of a community center for the district as well as an information center on the town's recovery for domestic and international tourists (Miyagi, 2019). Another such facility, built in the city's Megumino district, is the Hebita Community Center, which has helped community members connect and strengthen social ties in an area that was heavily affected by the tsunami (Sanriku Kahoku Shimpo, 2020).

Another example of the city's community-oriented approach is the Ishinomaki Genki Ichiba, a centrally-located public market which showcases local products and provides operating space and food courts for local restaurants; this site also gives vendors and fishers who lost their storefronts in the tsunami a joint place in which to sell their wares (Nippon.com, 2018). And urban planners have mapped over a dozen similar community-oriented recovery projects in Ishinomaki, among other coastal communities, ranging from community cafes for elders like Yottegain Community Salon, sustainability-focused community centers like Ishinomaki Cafe, and nonprofit recovery planning spaces like Ishinomaki Future Support (Dimmer and Lindenberg, 2021).

In addition to these grassroots projects, city officials intentionally relocated several communities together to maintain social cohesion, transferring from floodplain districts like Kadonowaki to elevated areas like Hebita and Nozomino districts (Ubaura et al., 2016). Social infrastructure provides public space for local residents to build community cohesion. Such spaces have been highly effective at increasing resident social cohesion and health after the 3/11 disaster in other municipalities (Aldrich and Kiyota, 2017). After past disasters like the Kobe earthquake, neighborhoods with strong social cohesion historically saw less net-outmigration during times of crisis (Aldrich, 2012). Finally, there were also strong programs supporting the local fishing industry, both through the redevelopment of facilities and financial programs to support local fishermen and businesses (Ishinomaki City, 2013).

It was this mixed approach that Ishinomaki adopted which complemented other treatment effects and led to relatively stable income per capita *and* low levels of net-outmigration. Ishinomaki saw many hard infrastructure projects, aided by highly networked engineering researchers, but also many soft community projects that aided recovery. For example, Fig. 1 revealed that communities with at least moderate committee connectivity tended to see soft policies, including public centers, markets, and renewable energy. This is a helpful reminder that good soft policy can augment otherwise infrastructure-focused recovery, but also that well-networked committee members might also encourage other recovery approaches. Ishinomaki demonstrates well the value of **(H2)** *well-connected policy networks*, which also tended to adopt **(H1)** *soft policy designs*, among others, to improve recovery.

6. Onagawa Town: A divergent case

In contrast, the case of Onagawa Town highlights a different kind of recovery, where decision-makers eschewed recommendations of researchers, leading to mixed economic recovery but also heightened cohesion. Onagawa is a coastal town of 6,319 residents in northeast Miyagi Prefecture, directly adjacent to Ishinomaki City (Onagawa Town, 2020). Onagawa's fisheries, port, and central town area were all inundated by the tsunami, requiring major reconstruction efforts. Curiously, however, Onagawa did *not* choose to build new seawalls, concerned that they would end the town's fishing prospects and curtail its main industry, other than those built privately for the Onagawa Nuclear Power Plant (Shimbun, 2013).

Onagawa's nuclear power plant has given the community more financial security over time. As of 2019, funds from the nuclear plant represented over 10% of the town's revenue (Mainichi, 2020). However, the nuclear power plant itself is located at the tip of the Oshika peninsula, quite far from Onagawa's town center, meaning that plant reconstruction and reconstruction in Onagawa were relatively unrelated; the nuclear power plant's main effect on recovery was extra capital for construction provided by Three Power Development Laws *(Dengen Sanpō)* subsidies in exchange for hosting the nuclear facility. This led to slightly larger facilities than would otherwise be possible, like a train station with its own public bath, unusual for such a small town. However, local officials were free to use those funds for hard or soft policy, leaving open the question of how the town would tackle recovery. In fact, unless community officials found ways to build social cohesion, maintain population, and keep local fishing jobs, the community could become financially dependent on the nuclear power plant, a poor strategy for aging reactors.

Given this context, the town enlisted diverse committee members to develop soft policies for recovery. Onagawa's committee contained 14 members from a diverse array of backgrounds. 21.4% of members were affiliated with the fishing industry, 21.4% were from social organizations, 21.4% were government-affiliated, 28.6% represented from local businesses, and 42.9% were from research institutions. This committee's diversity had limits, however; like many committees in Tohoku, only 1 out of 14 members was a woman, and most members were over age 60.

Even so, the broad representation of Onagawa's recovery committee strongly related to the policies members proposed and the town adopted. The committee applied a soft-policy approach to town reconstruction, proposing policies focusing mainly on community development programs rather than large-scale infrastructure projects (Onagawa Town, 2011a; Onagawa Town, 2011b). Fourteen individuals served on the committee, representing various institutions in the region, in addition to more local stakeholders (Onagawa Town, 2011a; Onagawa Town, 2011b). Specifically, local committee members represented organizations such as Onagawa's Chamber of Commerce, Fish Market Cooperative and the elected neighborhood representatives (*ku-cho)* Councillors Association (Onagawa Town, 2011a; Onagawa Town, 2011b). While there was a push for some infrastructure restoration projects, the majority of Onagawa's proposed and implemented policies focused on community development and social ties (Onagawa Town, 2011a; Onagawa Town, 2011b). Specifically, the Machinaka Exchange Center and the Seapal-Pier, both in Oshika District, serve as prime examples of this approach. The first, the Machinaka Exchange Center, serves as a town community center, hosting community festivals and regular meetings for local associations (Onagawa Machinaka Exchange Center, 2020). The second, Seapal-Pier, is a public market, center of business, commerce, and social life in the new center of Onagawa (Onagawa, 2020).

While some experts argued Onagawa should have built seawalls to protect itself from future catastrophes, its recovery committee advocated instead for a community-centric approach. Because they did not have standard infrastructure projects seen in most other towns, the construction boom in Onagawa was more limited. Most reconstruction occurred through relocating homes to higher ground, while building new commercial spaces on higher ground but directly in the vicinity of Onagawa Bay's coastline. While these key factors did not lead Onagawa to receive better economic or human recovery than our models would have expected, they did help sustain Onagawa, which otherwise would have seen tremendous outmigration had they not rebuilt the town center. In Onagawa, representation in policy networks helped recovery more than connectivity, contrary to our second hypothesis; however, that community representation encouraged *(H1) soft policy design*, helping Onagawa reduce outmigration after crisis.

7. Discussion

This study tested whether **(H1)** the design of recovery policies or **(H2)** the networks that develop those policies shaped the recovery trajectories of Tohoku municipalities after the 2011 triple disaster in Japan. We used synthetic control experiments to test effects of 38 indicators of policy design or policy network traits on recovery, comparing observed human and economic recovery trajectories of towns which *adopted* those interventions with a synthetic control group, composed of weighted towns which *did not adopt* those interventions. We found that cities whose members of recovery committees were also involved in other cities' recovery committees tended to see a significant boost in economic recovery, which supports our hypothesis that **(H2)** policy network connectivity aids recovery. The same effect occurred if towns involved at least five researchers in their committees, if they involved at least one of the top three most interconnected members in the policy network, or if they built community centers as a recovery effort. Community centers' effect provides some support for our hypothesis that **(H1)** soft policy design also aids recovery.

We confirmed these findings using an emblematic case study of Ishinomaki, which illustrated how researcher-driven committees pushed for major infrastructure projects, but the city's adjacent push for community centers helped shore up social cohesion they otherwise might have lost, maintaining economic recovery. However, some cities highly connected to policy networks still experienced mixed recovery; we examined the divergent case of Onagawa Town, showing that although Onagawa experienced less-than-ideal recovery compared to peers, its policy network developed several innovative policies that helped the community recover long-term.

This study had several limitations. First, we only examined communities in Miyagi and Iwate, but not Fukushima. This is because communities in Fukushima faced fundamentally different challenges after the disaster from radioactivity. Future studies should investigate policy networks' role in Fukushima's recovery from the disaster.

Second, we applied dozens of synthetic control models, but could not assess, for example, the effect of policy networks while controlling for policy design, because these variables are highly collinear. However, this study did allow us to compare overall treatment effects of each, adding to our understanding of the net effect of each intervention.

Third, a potential intervening variable might be that our measures for income and social vulnerability might be influenced by consultants, temporary public workers, or others relocating to the area during the initial surge in reconstruction activity, who might contribute economically to restaurants, bars, transportation, and tax-base. We anticipated that hard policies would be strongly related to income and out-migration, due to the resulting construction boom in the first couple of years. However, we did not find any statistically significant relationship at conventional levels, indicating a weak effect at best. Though we see spikes in our measures of wealth and migration in the year following the disaster in Figs. 3 and 4, the synthetic control experiments' annual fixed effects adjusted for year-specific variation, like those due to temporary construction bubbles.

Similarly, this study examined effects of hard and soft policy designs on recovery between 2011 and 2017. Large infrastructure projects like seawalls hypothetically provide economic benefits to communities over a longer timespan if they properly protect from future storms and tsunamis, but this study could not account for such extreme events, since none occurred after 2011. Indeed, communities' inability to prepare for crisis through infrastructure alone spurred communities like Onagawa to *abandon* seawalls and instead focus on building social capital through community centers, public markets, and neighborhood relocation. Future studies should explore whether hard infrastructure helps recovery long-term, given eventual shocks.

Finally, we analyzed two main recovery indicators, including income per capita and net in-migration per capita, but other forms of recovery matter. Future studies should investigate the effect of these policies on social cohesion, among other indicators.

8. Conclusion

In summary, this mixed-methods study examined the human and economic recovery of 25 municipalities and the effect on recovery of overlapping advisory committees after the 3/11 disaster in Japan. We used 38 synthetic control experiments to test whether the design of policies or the policy networks that advised and shared these ideas to local government affected recovery. Independent of social capital, social vulnerability, damage, economic conditions, and demographics, we found that a towns' integration into regional policy networks was key to their economic recovery, more so than the specific design of any one type of policy. This indicates strong support for our hypothesis that **(H2)** policy networks aid recovery. Drawing on researchers, highly connected committee members, and sharing members in common with other towns accelerated the sharing of quality ideas. While most towns adopted an infrastructural approach to recovery, likely spread by engineering researchers on these committees, some towns like Ishinomaki counterbalanced this by investing heavily in community centers, bolstering their community cohesion. This suggests that **(H1)** soft policy design may aid recovery, as hypothesized, but well-connected committees do not always choose soft policies. In contrast, some communities, such as Onagawa, directly rebuffed this infrastructural strategy; instead, drawing advice from diverse representation on their committees, they rebuilt according to the needs of local industry and residents. These locally customized recovery strategies did not lead to improved recovery by conventional metrics, but highlight a more equitable recovery decision-making that will serve the community well in the long run.

Past studies highlighted that networks may shape policy adoption and outcomes based on the level of contestation in a policy subsystem (Howlett, 2002), the changing structure of an advocacy coalition (Leifeld, 2013), the diversity and clustering of relationships (Sandström and Carlsson, 2008), and decisionmakers bandwagoning and influencing each others' choices over time (Scott, 2013; Angst and Hirschi, 2017; McGee and Jones, 2019). This study contributed to the policy networks literature, by showing that highly interconnected policy advisory committees shape public policy outcomes, as hypothesized, even though these policy advisory committees themselves are not directly part of the governing process. Further, we extended these findings to a new issue area and geographical context: municipal disaster recovery in Japan.

Additionally, this study highlighted the role of problem definition in disaster recovery. Past research shows that policymakers tend to define policy crises and disasters in terms that propel their political careers, avoid blame, and support their preferred policies (Stallings, 1990; Rochefort and Cobb, 1994; Kay, 2003; Samuels, 2012; Thistlethwaite et al., 2019). Some crises, like Hurricane Katrina, reshaped the conversation around disaster planning and sustainable development (Farley et al., 2007). This study illustrated how researchers' tendency to define recovery as an infrastructural problem led to more hard, infrastructural policy solutions, while committees with more diverse representation supported an array of other community-oriented policy designs. Scholars and policymakers should consider how top-down ideas about recovery, like infrastructure projects, can overtake other much needed bottom-up, community development initiatives.

Future research should investigate how different combinations of policy designs interact to produce better or worse recovery. Further, this study examined Miyagi and Iwate prefectures' recovery, but future research should compare the effects of policy networks on recovery in Japan and other disaster affected communities in the US or comparable settings. By improving community representation in policy networks, communities can combine more local expertise and awareness with diverse policy ideas gathered through these networks. Given the strong impact of researchers on this network, democratizing these committees is an important step towards more equitable, participatory governance in disaster recovery.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloenvcha.2021.102342.

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