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Institutional drivers of adaptation in local government decision-making: evidence from Chile

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Abstract We study how the local institutional context shapes local government decisions about responses to perceived threats of natural disasters and climatic change. We draw on institutional theories and field observations to develop hypotheses about the effects of municipal institutional arrangements, social capital, and multilevel governance. To test these ideas, we analyze a unique dataset with over-time observations for almost all local governments in Chile. Our analysis shows multiple institutional conditions supporting proactive local adaptation: municipalities with relatively robust institutional settings tend to devote more resources to environmental risk management and adaptation. We use our quantitative model to show that altering institutional settings can make a difference for increasing local government investments in this area. Although few local governments in Chile currently enjoy favorable institutional conditions for risk reduction and adaptation, our findings identify ways through which external actors may contribute to a more propitious institutional climate.

Keywords Local governance · Disaster risk management · Adaptation · Chile

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1 Introduction

The increased concern about climatic change and recurrent disasters has spurred scholars and policy makers to deepen their understanding of disaster risk management and adaptation at the local scale. The existing literature and international frameworks are reaching a consensus about a number of issues. First, adaptation to climate change and higher risks of natural disasters is urgent (Revi et al. 2014:11–16). Second, to achieve effective investments and actions at local scales, municipalities and cities are important (Betsill 2001; Durban Adaptation Charter 2011; Revi et al. 2014:538; UN–Habitat 2016:x). Third, an integrated perspective that includes mitigation, adaptation, environmental protection, vulnerability, and risk reduction is highly desirable (Field et al. 2012:10–11; Simon and Leck 2015). Fourth, more research on fostering adaptation is needed, especially on the institutional barriers and opportunities at the local level (e.g., Betsill and Bulkeley 2007:445, 448, 453–454; Bulkeley and Betsill 2003:5; Field et al. 2012:17, 53–54, 87, 94, 323; Revi et al. 2014: 550, 575; Satterthwaite et al. 2007:vii; Simon and Leck 2015: iv–v; Supplementary Material (SM):21–23).

Our research aims to explain decisions in environmental disaster risk management (EDRM) and adaptation, in particular, why some local governments allocate more financial resources and investments than others. In this study, we use the term EDRM when we refer to these decisions.

A few studies analyze the institutional conditions under which EDRM is more likely to succeed (e.g., Betsill 2001; Betsill and Bulkeley 2007; Carmin et al. 2012; Satterthwaite 1997; Valdivieso and Andersson 2017). We build on this literature to articulate three hypotheses about local government decision-making. Our *first hypothesis* is that municipal institutional arrangements (MIAs) in terms of transparency, municipal coordination, and autonomous municipal councils are relevant determinants of EDRM decisions. Our *second hypothesis* states that the greater the extent of social capital (SC) in the local territory (characterized as participation and synergistic relationships between society and local institutions) the more local governments invest in EDRM activities. Our *third hypothesis* proposes that investment decisions increase with multilevel governance (MLG)—when local governments perceive financial incentives from and communicate and coordinate with actors who operate at other levels of governance.

Chile provides an excellent setting for analyzing these issues. Not only is it a country that is highly exposed to natural hazards but it also recently introduced several national initiatives and policies to enhance local capacities for EDRM and adaptation (SM: 26–32, 32–36).

We use mixed methods. For our qualitative comparative analysis, we draw on firsthand observations in three selected municipalities, which included interviews with key governance actors as well as with a representative sample of household members in each of the territories. For our quantitative analysis, we use a unique set of observations for almost all Chilean municipalities (329 out of 346) for 2009–2014. The findings from the qualitative work informed the structuring of the subsequent statistical analysis to test the hypothesized relationships quantitatively.

This paper makes two novel contributions to the existing literature. First, we add robust, new evidence on the institutional factors associated with proactive local government decisions and actions. Second, we demonstrate the magnitude of potential improvements in EDRM governance that Chilean governance actors could achieve by altering their existing MIAs, SC, and MLG. To preview our results, the evidence from both qualitative and quantitative analyses support our three hypotheses that MIA, SC, and MLG factors help explain variations in local government decisions on EDRM. We use these results to show how future expenditures and investments might be strengthened, and find that interventions that target four particular institutional dimensions to be particularly promising: increase management transparency, strengthen municipal internal coordination, promote more public participation in municipal decision-making processes, and facilitate more

cooperative links between municipal decision makers and governance actors at the national and regional levels of government.

2 Previous studies

Drawing on findings from a mix of case studies, expert assessments, and experiences of cities involved with climate change adaptation activities (e.g., Cities for Climate Protection program run by ICLEI), the literature identifies several institutional factors that appear to hinder or help local EDRM and adaptation. These factors may be broadly grouped into three categories: MIA, SC, and MLG. In terms of MIAs, several studies draw attention to institutional barriers and enablers affecting local governments, such as organizational frameworks and knowledge, institutional organization, good governance, national and state policies, municipal networks, and leadership championing institutional change (e.g., Aylett 2010; Betsill 2001; Betsill and Bulkeley 2004; Burch 2010; Carmin et al. 2012).

The ability of local governments to perform EDRM tasks effectively is in part a function of the broader social and institutional context—for example, the extent to which the individuals within a jurisdiction are able to work together effectively and how much local actors trust one another (e.g., Adger 2003; Woolcock and Narayan 2000). We refer to this aspect of institutional context as SC, defined as reiterated interpersonal relationships promoting trust, reciprocity, and returns that can efficiently transmit information and ease coordination to produce outcomes at many levels (Ahn and Ostrom 2008; Dasgupta 2003). In particular, the linking SC literature highlights the relationships between social participation, local institutional context, and governance outcomes (e.g., Szreter and Woolcock 2004). Finally, the literature on MLG looks at network relationships between organizations at different scales (e.g., Betsill 2001; Bulkeley and Betsill 2003; Carmin et al. 2012) and how these arrangements affect local government decisions and performance.

Taken together, the literature suggests that there are several institutional factors that potentially matter for local government responses to address disaster risks and climate change (more details on the literature on EDRM in SM: 9–21). Relatively little is known, however, under which particular institutional conditions local governments are more likely to decide to allocate more of their scarce resources to invest in EDRM and adaptation interventions. Here, we seek to address this shortcoming by bringing together both qualitative and quantitative evidence to identify and examine the impact of three specific aspects of the local institutional context on local decision-making.

3 Our approach

We rely on a neo-institutionalist framework that integrates theories of institutional change, SC, and polycentric governance (e.g., Andersson and Ostrom 2008; McGinnis 1999; Ostrom 1990, 2005; Valdivieso and Andersson 2017; Valdivieso and Villena-Roldán 2014). We propose that local government decisions and outcomes are affected by social interactions and organizations operating at other levels of governance—both within and outside the municipality. At each level, organizations operate according to their institutional settings, available information, constraints, and incentive structures. The information, resources, and capabilities of any single level may help overcome problems of information and/or restrictions on another level (Andersson and Ostrom 2008:73; McGinnis 1999:xii–xiii; Ostrom 1990:133, Ostrom 2005:60–61). Particularly relevant is the focus

on multiscale relations that affect the incentive structures of decision makers (e.g., Andersson and Ostrom 2008:74; SM: 23–26).

We expect that MIAs for transparency, accountability, and interdepartmental coordination facilitate information flows on local environmental and social conditions, fostering local governments' decisions to pursue sustainability. We also conjecture that institutional settings linking citizens' concerns with institutions affect local government allocations on EDRM. A final hypothesis is that polycentric interactions between municipalities and organizations with jurisdiction in EDRM located at other institutional levels affect local government decisions about resource allocation.

4 Data and methods

We study Chilean municipalities affected by climate change and other environmental stressors. Chilean municipalities exhibit a great deal of variability in institutional conditions for local government decisions as well as the resulting EDRM performance. The mandate of these local governments is to be the first responders to all emergencies and disasters. They are also supposed to invest in programs supporting disaster risk management and adaptation (SM: 36–39). We employ both qualitative and quantitative methods to examine the influence of institutional settings and polycentric relationships on how local governments in Chile decide to respond to risks associated with extreme events and climate change.

4.1 Qualitative analysis

In selecting case study sites, we focused on municipalities located in central-southern Chile, where 86% of the country's population lives, affected by deterioration of environmental conditions, disaster risks, and climate change. We selected representative cases based on the Chilean geography (e.g., mountain, valley, and coastline), environmental conditions, socioeconomic indicators, and availability of data. Through this process, we chose to study the municipalities of Cauquenes, Lebu, and Panguipulli. These municipalities exhibit contrasting EDRM performance and our qualitative analysis explores possible drivers of such variation.

We reviewed official records provided by municipal secretaries, conducted personal interviews with municipal officials, social leaders, and a representative sample of heads of households in all three sites. Through the interviews, we collected data on socioeconomic characteristics, risk perception, experiences, institutional responses, and social participation. In parallel, we consulted Chilean experts and officials, and organized workshops to clarify concepts and measures, as well as discussing the relevance of our research. For the qualitative examination of our hypotheses, we conducted a contextualized analysis of relationships among decisions, contexts, and institutional factors, triangulating primary sources of information and designing indicators to compare observations in the three locations (Valdivieso and Andersson 2017; SM: 43–105).

4.2 Quantitative analysis

We used a panel of 329 out of 346 Chilean municipalities for the years 2009–2014 for our quantitative analysis. There is great variation in geographical, environmental, and socioeconomic fragility in these data. The data contain multiple budgetary and investment decisions of local governments. We relied on available government data complemented by targeted data inquiries (e.g., correspondence and telephone calls).

We use these observations to test our hypothesized relationships between local institutional context and EDRM expenditures. More specifically, we propose that EDRM among local governments is the result of municipal councils' decisions under certain institutional conditions and available information and resources, given the existing incentive structures. The perceived benefits depend on the potential risk reduction, adaptation opportunities, and the municipal context. Each municipality has a particular set of contextual characteristics, X, including MIAs, SC, and polycentric relationships that recognize the heterogeneous costs and benefits derived from investment decisions in EDRM.

Under these assumptions, a local government i at time t chooses a level of investment Y_{it} that is explained by a linear index of vector of characteristics X_{it}, municipality-specific time-invariant characteristics β_i, and an idiosyncratic random component ε_{it}:

$$Y_{it} = \sum_{k=1}^{K} \alpha_k X_{kit} + \beta_i + \varepsilon_{it} = X_{it}\alpha + \beta_i + \varepsilon_{it}. \quad (1)$$

Time-invariant characteristics, observed or not, are subsumed into the individual effect β_i, allowing us to consider both observable and unobservable time-invariant municipality characteristics.

We use linear fixed effects (LFE) and linear random effects (LRE) models for estimating the average marginal impact of explanatory variables in Eq. (1). LFE is a robust form to control for endogeneity caused by omission of time-invariant characteristics, but do not allow us to recover the impact of specific time-invariant factors of interest, although we control for them. The LRE estimator provides a consistent estimation as long as their unobserved municipal effect is uncorrelated with the explanatory variable. If the latter assumption is correct, the LRE model provides a more statistically efficient estimation than the LFE model and allows us to estimate the average impact of time-invariant controls, such as some of the MIA variables (e.g., municipal organization index). Therefore, we estimate both sets of models. All specifications include year fixed effects as well (more information in SM: 105–109).

4.3 Dependent variables

As *dependent variables*, we chose comparable metrics. Municipal officials spoke of risk management concepts, programs, plans, and actions in relation to expenditures and investments, reporting that the municipal councils make decisions about these topics. The operationalization of the concept of local government decisions as manifest variable expenditures and investments consisted of the following steps: first, review of frameworks, literature, and typologies; second, inclusion of questions related to decisions, expenditures, and investments in interviews (e.g., directors for environment, emergencies, planning, and public works and mayors); third, searching data in reliable official records (e.g., municipal accounts, records provided by planning offices and municipal secretaries, national registries); and fourth, construction of a panel database for 2009–2014.

The emergency expenditures provide resources for preparedness (e.g., equipment, planning, and early-warning systems) and responses, and are allocated annually based on estimations of risk reduction activities and possible emergencies. Investments in adaptation and vulnerability reduction are projects that favor risk reduction and adaptation over the long term. The data were coded according to the typology of the National Investment Database. For the regression models, we explain three dependent variables in natural logarithms: "emergency funds m$/hab" is a variable indicating per capita annual budgetary resources. The variables "adaptation invest m$/hab" and

"vulnerability reduction invest m$/hab" indicate the corresponding per capita costs of local government projects entered in the National Investment System each year in thousands of Chilean pesos (additional information regarding operationalizations, variables, and sources in SM: 113–116).

Based on our framework and evidence of the qualitative study, we operationalized the concepts of institutional settings and polycentric relationships in manifest variables associated with MIAs, SC, and MLG.

4.4 Municipal institutional arrangements

The first variable "Transparency" consists of local government rankings by the National Council for Transparency. The second variable "Internal Coordination" quantifies with binary criteria information on internal regulations and organigrams using an index that includes measures of internal coordination. The third variable "Council Autonomy" quantifies regulatory prescriptions on operational rules for accountability (e.g., for study commissions, access to information from departments, public hearings, and participation during council meetings) (SM: 81–88, 114).

4.5 Social capital

We expect social participation and polycentric relationships to affect local government decisions. Accordingly, we searched on individual decisions to participate that generate returns, and collective action structures that represent repeated relationships with potential effects on local government decisions. Individual participation in social organizations and the number of social organizations meet the criteria. We reviewed minutes of municipal council meetings covering 2014 to document synergic relationships with the local governments. In the regression models, we included "social participation rate," i.e., percentage of participation in social organizations (surveys at municipal level), and "community organization rate," the rate of registered organizations per 1000 inhabitants (Chilean Civil and Identification Registry), as variables (more details in SM: 59–60, 64–65, 67–68, 70–72, 88–94, 114).

4.6 Multilevel governance

Exploring the concept of polycentric governance in empirical contexts, interviewees reported that municipalities interact and coordinate with external actors around programs, plans, actions, transfers, and investments. Documenting these interactions—based on interviews, official records, minutes of municipal council meetings—we measured the degree of polycentric governance by tallying (1) agreements, (2) relationships of municipal councils with external agents and organizations, and (3) transfers to local governments. For the quantitative analysis, we focus on five types of financial transfers per capita from ministries supporting local government initiatives to improve sustainable development and welfare (in natural logarithms). We consider (1) neighborhood improvements (log [SUBDERE neighb transf/hab]), (2) management modernization (log [SUBDERE manag transf/hab]), (3) security and risk reduction (log [MININT local transfer/hab]), (4) adaptation in the agricultural sector (log [MINAGRI local transf/hab]), and (5) environmental sustainability (log([MMA local transfer/hab]). We also include transfers from regional governments for development of local initiatives and infrastructures (log [curr reg transf/hab]). The data sources are available at national government websites. We expect with more transfers, more investments in EDRM would occur, but this is not guaranteed because local governments may reallocate funds to other, non-EMDR uses (SM: 94–103, 113).

4.7 Control variables

According to previous studies, several additional variables also affect EDRM decisions, and it is important to control for the potential influences of these factors. We use the following control variables: (1) annual municipal budget; (2) number of municipal employees per inhabitant; (3) the political competition variables "mayor votes percentage," Herfindahl index of mayor votes concentration, and "mayor affinity in municipal council"; (4) mayor's education; (5) ideology of the mayor; and (6) municipal networks (participation or not).

Recognizing potential effects of environmental and socioeconomic context variables on decisions, we also control for annual precipitation (linear and squared, to capture effects of droughts and floods), Mercalli magnitude point of the 2010 earthquake (8.8 Richter scale), number of years since this earthquake, number and cost estimations of extreme events between 1971 and 2011, population density, poverty rate, urban population rate, and location of the municipality (coast, valley, or mountain). While these variables can clearly affect EDRM investments, we do not report these results in the main text but focus instead on the results pertaining directly to our hypotheses (more details in SM, pp. 109–113, 114–115, 116–123).

5 Results

We find evidence in support of the idea that EDRM decisions are associated with all three classes of institutional variables. The qualitative and quantitative evidence suggest three broader patterns: municipalities with more transparent management practices and stronger internal coordination mechanisms spend more resources on emergencies; municipalities with more social participation and community organizations also spend more; and the more funding that a municipality receives from national and regional governments, the more resources it allocates for adaptation and vulnerability reduction.

The results of the LFE and LRE regression models from Eq. (1) are presented in Table 1. The estimated coefficients for each EDRM dimension (e.g., emergency funds, adaptation, and vulnerability reduction) are marginal log point changes (approximately percentage changes) due to a change of one unit of the corresponding independent variable.[1] We list estimated coefficients with standard errors (clustered for each local government unit; see Wooldridge 2010) in parentheses, which takes into account time correlations of residuals due to unobserved municipal heterogeneity.

5.1 Municipalities with more transparent management practices and stronger internal coordination mechanisms spend more resources on EDRM.

Municipal officials identified several barriers related to institutional settings that prevented them from being more effective in the area of EDRM (personal interviews, July and August 2014, June 2015). Our comparative analysis shows three factors that appear to affect differences in EDRM decisions: transparency of management practices and routines, internal coordination mechanisms, and the autonomy of municipal councils.

[1] Let us suppose that the independent variable of interest X varies in a magnitude Δ and β is the coefficient associated with X. Then, the percentage change of the dependent variable is $\exp(\beta\Delta)$-1, where the function exp represents the exponential function. The value obtained is a percentage change of approximately $\beta\Delta$ if Δ is small.

Table 1 Estimation results of fixed effects (FE) and random effects (RE) regression models

	Variables	Model 1 FE log(emergency funds m$/hab)	Model 2 RE log(emergency funds m$/hab)	Model 3 FE log(adaptation invest m$/hab)	Model 4 RE log(adaptation invest m$/hab)	Model 5 FE log(vulnerability reduction invest m$/hab)	Model 6 RE log(vulnerability reduction invest m$/hab)
MIAs	Transparency	0.00178***	0.000716**	-9.47e-05	−0.00174	−0.00144	−0.00232
		(0.000569)	(0.000361)	(0.00281)	(0.00217)	(0.00344)	(0.00257)
	Internal coordination		0.901***		0.525		0.211
			(0.126)		(0.401)		(0.471)
	Council autonomy		0.0284		−0.273		−0.00271
			(0.0571)		(0.242)		(0.271)
SC	Social participation	0.00127	0.00287*	0.000718	0.00462	0.000611	0.00993
		(0.00221)	(0.00161)	(0.0108)	(0.00722)	(0.0135)	(0.00810)
	Community organization	0.00166***	0.00127**	0.000297	0.000990	−0.00350	−0.00231
		(0.000528)	(0.000509)	(0.00239)	(0.00223)	(0.00265)	(0.00232)
MLG	SUBDERE[a]	−0.000532	−0.00223	0.0391	0.0859***	0.0443	0.0895***
		(0.00913)	(0.00677)	(0.0305)	(0.0284)	(0.0380)	(0.0311)
	SUBDERE[b]	−0.00956	0.00261	−0.0110	−0.000688	−0.0332	−0.0155
		(0.00983)	(0.00581)	(0.0270)	(0.0261)	(0.0290)	(0.0275)
	Min. of interior[c]	0.0217	0.0268	0.0193	0.0579	0.00588	0.0179
		(0.0241)	(0.0220)	(0.0774)	(0.0687)	(0.0882)	(0.0816)
	Min. of agricult.[c]	−0.0159	−0.00652	0.0401	0.0692	0.0921	0.114
		(0.0210)	(0.0158)	(0.0926)	(0.0810)	(0.105)	(0.0860)
	Min. of environm.[c]	−0.259	−0.126	0.577	0.756	1.320*	1.272**
		(0.357)	(0.331)	(0.663)	(0.619)	(0.678)	(0.647)
	Regional govern.[c]	−0.0189	−0.0164	0.335*	0.401***	0.0944	0.224
		(0.0415)	(0.0276)	(0.178)	(0.146)	(0.191)	(0.155)
	Observations	1830	1808	1830	1808	1824	1802
	R-squared	0.203		0.076		0.043	
	Number muni	329	324	329	324	328	323
	R-sq. overall	0.074	0.460	0.151	0.255	0.146	0.237
	R-sq. between	0.012	0.710	0.197	0.405	0.256	0.418
	R-sq. within	0.203	0.206	0.077	0.064	0.043	0.034
	Error SD	0.468	0.323	1.771	1.537	1.909	1.683
	Test all	0.000	0.000	0.225	0.000	0.382	0.000
	Test MLG	0.447	0.775	0.345	0.001	0.324	0.0136
	Test MIAs	0.002	0.000	0.973	0.462	0.677	0.686
	Test SC	0.007	0.007	0.990	0.731	0.414	0.344

Robust standard errors in parentheses. Individual significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Additional controls added are explained in the corresponding section. Control coefficients are in Table A42 (SM, pp. 117–119). *p*-values of Wald test hypothesis reported

[a] log (SUBDERE neighb transf/hab)

[b] log (SUBDERE manag transf/hab)

[c] Logarithm of per capita transfers received by the municipality

Differences in the transparency of internal practices among the three municipalities affected their respective routines, relationships with external agents, decisions, and EDRM performance. While Panguipulli made significant strides to improve internal procedures and services, achieving national legal standards on information access, Cauquenes and Lebu had relatively closed administrations, less access to internal information, and incomplete public official records. In Cauquenes, three out of 36 audit reports from the Comptroller General's Office referred to incorrect use of public funds.

The internal organization of the municipal administration and the degree of effective integration of its EDRM actions within its broader work program seem influential for the overall performance of the municipality. Cauquenes' and Lebu's environmental offices were isolated in departments and unable to generate information or provide feedback on local government decisions. In Panguipulli, on the other hand, the Planning Office had a Department of Environmental Planning that reported on the environmental situation. The emergency office carried out risk prevention activities in coordination with other offices, and active technical committees coordinated activities.

The results from our quantitative analysis (Table 1) are partly consistent with these qualitative findings. Two of the three MIA variables appear to have a positive influence on emergency expenditures: the coefficients for the variables "transparency" and "internal organization" in at least two of the models. In Model 1, transparency has a positive coefficient of 0.00178 (significance at $p < 0.01$). A one-unit increase in a municipality's transparency rating induces an increase in emergency expenditures by 0.00178 log point (*lp*). In Model 2, transparency also induces increase (0.000716 *lp*, $p < 0.05$). And a one-unit increase of the municipal internal organization variable is associated with an increase in emergency expenditures by 0.901 *lp* ($p < 0.01$).

Although our case studies indicated that the political autonomy of the municipal council is an important factor in explaining variation in local government decisions, our statistical analysis does not confirm these findings (more information regarding these results in SM: 81–85).

In sum, while the results from our quantitative analysis suggest that MIA factors are not significant for explaining adaptation and vulnerability reduction investments, they substantially affect decisions on emergency funds availability. Since MIAs are often complex, they can be hard to capture quantitatively in a few indices, the result of no effects of political autonomy of the municipal council is not fully unexpected. This is yet another reason for employing mixed methods to provide a more complete picture of a complex reality.

5.2 Municipalities with more community organizations and public participation invested more in emergency prevention

Our second hypothesis states that social participation and synergistic relationships between society and local institutions increases EDRM performance. The evidence from both qualitative and quantitative analyses lends support to its validity.

All three case-study municipalities had social resources that could potentially be mobilized toward EDRM, but Panguipulli stands out in terms of having a more organized civil society. The average rates of legally registered territorial organizations for every 1000 inhabitants were 11.7 in Cauquenes, 12.6 in Lebu, and 21.7 in Panguipulli. Another contrasting characteristic related to SC is the degree of public participation in municipal affairs. Surveyed household members in Panguipulli reported more meaningful exchanges with the municipal officials than

in Lebu and Cauquenes (85%, 28%, and 13%, respectively), and the council meeting minutes document more synergic relationships with the local government (more details in SM: 59–61, 64–65, 67–68, 70–72, 88–94).

The results in Table 1 add to the qualitative evidence in support of our second hypotheses. In Models 1 and 2, both these variables positively affect EDRM expenditures. For example, 1% more of social participation rate induces an emergency expenditure increase of 0.00287 *lp* ($p < 0.10$) and for each additional registered community organization per 1000 inhabitants there is a corresponding increase in emergency expenditures of 0.00166–0.00127 *lp* ($p < 0.01$ and $p < 0.05$).

5.3 Municipalities with more national and regional funding and cooperation allocated more resources to EDRM activities

Our third hypothesis proposes that EDRM investments increase when local governments have incentives, communicate, and coordinate with actors at other levels of governance. The findings from both qualitative and quantitative analyses support this idea, although the latter was limited to the analysis of the effects of financial transfers on EDRM investments.

Available records documenting the years 2012–2014 report that the three municipalities signed agreements with external organizations to cooperate in the areas of local development, risk reduction management (e.g., emergencies, health), adaptation (e.g., green infrastructure, land planning, agricultural sector, monitoring), and vulnerability reduction (e.g., basic services and housing). Compared with Cauquenes and Lebu, Panguipulli stands out for having not only a greater number of agreements, but also a more diversified portfolio, including agreements with non-government organizations, private sector, and universities.

Our qualitative evidence also suggests that the extent of communication between municipal council members and external organizations is an aspect of MLG that can affect the municipality's effectiveness in EDRM. Documenting the frequency of communication between municipal councils and external actors on EDRM issues, we found that Panguipulli stands out for the quantity of recorded two-way and multi-way relations. Another important aspect of MLG is the funding streams that cross levels of governance. Our case studies highlighted the importance of these funding streams for the functioning of local EDRM activities. These funds could help finance municipal projects such as neighborhood improvements and waste treatment facilities, in line with national policies in EDRM. Local governments had full autonomy to design initiatives and prioritize issues based on local contexts, agendas, and preferences (SM: 36–39, 63–64, 66–67, 69–70, 94–103).

The results from the regression analysis support the positive effect of transfers on EDRM expenditures (see Table 1). In Models 3–6, transfers from both national and regional government agencies stand out as important sources of support. For example, a 1% increase in national government transfers is associated with a 0.0859 *lp* increase in adaptive investment ($p < 0.01$). Transfers from the regional government also had a sizable impact (0.401 *lp*, $p < 0.01$).

6 Discussion

Our findings challenge much of the literature on adaptation and risk reduction to move beyond single-factor explanations to observed variations in local government decisions in the area of

EDRM. Chilean municipalities share similar contexts of exposition and vulnerability regarding risks by climatic change and other stressors, and proactive national policies for environmental risk management and adaptation. However, local governments differ in their decisions; some invest in EDRM, and others do business as usual. Trying to explain this variation, most of the existing literature on EDRM suggests financial and human resources are key explanatory factors (e.g., Carmin et al. 2012; Satterthwaite et al. 2007). While our analysis lends some support to this idea—money and technical expertise do seem to matter for performance—our study also points to a number of MIA factors (e.g., norms, operational rules, interactions in structured situations) that are systematically linked with varying levels of expenditures and performance.

Similarly, a strand in the literature on SC suggests that higher levels of social participation are the most important driver of municipal action (e.g., Adger 2003). However, the Chilean experience teaches that, despite expectations in social participation effects (e.g., legal reforms, participatory democracy, community-based disaster reduction plans), the quality of social participation is not guaranteed, and social participation does not translate automatically into better results in EDRM (Valdivieso and Andersson 2017).

Along the same lines, our results on the effects of MLG might lead some to conclude that network relationships or institutional interplay at several scales are the key explanatory factors for EDRM performance (e.g., Adu-Boateng 2015), consistent with some previous work on the importance of network effects (e.g., Betsill 2001; Betsill and Bulkeley 2004). However, our results also reject this as an overly simplistic explanation. For example, the only three Chilean municipalities associated with the ICLEI network of local governments during 2008–2014 did not stand out in their progress in adaptation (SM: 18–21, 118, 121–122).

The existing literature on the local governance of EDRM faces at least two challenges. First, most existing investigations tend to rely on either static comparisons or qualitative narratives to identify factors associated with governance outcomes. It is extremely rare that research in this area employs a systematic comparative analysis of longitudinal data. This is a serious limitation for the EDRM literature because MIAs are dynamic human constructs that come about as a result of perceived problems and opportunities. It is therefore essential to analyze how perceptions, institutions, decisions, and actions relate to EDRM change over time. Moreover, lacking a longitudinal perspective makes the analysis of institutions problematic due to the possibility of reverse causality and endogeneity. Another limitation is the narrow focus of some of the existing empirical strategies pursued: research that seeks to test the effect of a single, narrowly defined factor is likely to overlook the ways the variable of interest may form part of a more complex and greater configurational explanation (Ostrom 1990:38; Valdivieso and Andersson 2017:22–24).

To some extent, we overcome these limitations by combining qualitative analysis of a small number of municipalities from a historical perspective with a quantitative longitudinal comparative analysis of almost all local governments in Chile during a 5-year period. Our use of fixed effects and random effects with time-invariant controls allows us to handle potential endogeneity due to omitted variable bias. Nevertheless, the results presented so far do not consider the combined effects of the variables that our mixed-method analysis suggests are important institutional drivers. For example, by how much would a municipality increase its investment in EDRM if it improved on all the variables in the categories of MIAs, SC, and MLG? Are the potential improvements in performance substantively meaningful to warrant an effort to strengthen the local institutional context for EDRM decisions in Chile? To address these questions, we use our statistical model to simulate what such improvements could look like.

7 Counterfactual simulations

One way to illustrate the importance of a multilevel analysis with empirical findings is to show the EDRM investment levels we would observe in municipalities with desirable institutional settings. We ask what the expected investment level would be in a municipality with some "ideal" conditions in terms of MIAs, SC, and MLG. To answer this question, we use our estimated models to compute the predicted outcomes for a given set of values of the main independent variables of interest. To illustrate the effect that altering the strength of these three institutional composites, we contrast outcomes for municipalities that have among the best institutional conditions (in the 95th percentile of our sample) with those municipalities that exhibit some of the worst institutional conditions (in the 5th percentile). We keep the rest of the explanatory variables, including controls, constant at their means.

In Fig. 1, we use the fixed effects model (Table 1, Model 1) for computing counterfactuals for per capita investment in emergency funds and simulate what would happen if a given municipality managed to improve its institutional condition to the degree that it would be in the top 95th percentile of our sample for the variables associated with MIAs, SC, and MLG. Figure 1 reveals that all three factors are substantively potent in affecting adaptation allocations: A municipality in the top 95th percentile for the MIA measures would generate an increase with respect to the average of $e^{0.088} - 1 \approx 9.2\%$ in such investment, whereas a bottom 5th percentile configuration would generate a drop of

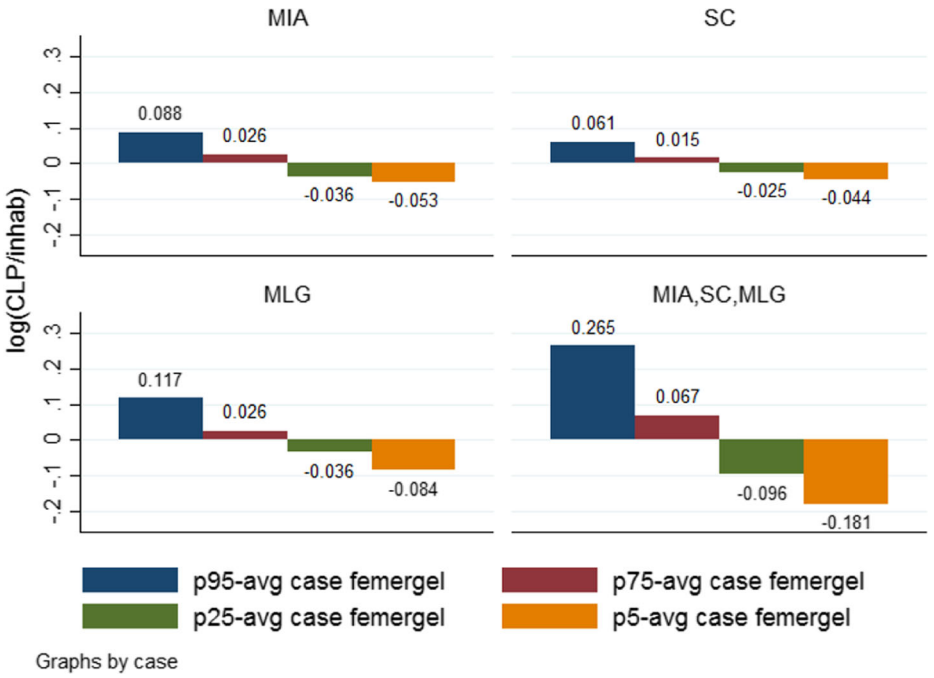

Fig. 1 Counterfactual investment gap with respect to emergency funds per inhabitant, FE model (Table 1, column 2)

$e^{-0.053} - 1 \approx -5.2\%$, which are important effects.[2] The counterparts for SC variation between a very good scenario (95th percentile) and a very bad one suggest an increase of 6.3% and a drop of 4.6% with respect to the average, respectively. The impact of MLG variation is bigger than the precedent factors. Interestingly, a top configuration in the 95th percentile of all factors would generate a large increase with respect to the average ($e^{0.265} - 1 \approx 30.3\%$), while a very bad configuration would decrease it by roughly −16.6%. Simulations with fixed and random models for emergency expenditures, adaptation, and vulnerability reduction investments show similar patterns of the largest effects by altering all factors (SM: 123–126).

In sum, the simulations show the important role played by a variety of institutional factors in efforts to improve EDRM performance among local governments in Chile, especially when simultaneously considering the effects of these conditions. These simulations also bring home an important lesson for policy making: it shows how broad-based efforts to strengthen local MIAs may be more effective than specific and narrowly defined interventions that target only one or two "key factors." This is exemplified by common calls for the injection of money and strengthening of human resources to improve adaptation, or focusing only on the interplay between national and local governments in disasters, without regard for the institutional settings that undergird much of the functionality of public organizations.

8 Conclusions

Our study adds nuance to how institutional context matters for local government decision-making on EDRM and adaptation. First, the qualitative analysis identifies the actual options related to EDRM faced by local governments in three similar municipalities regarding local contexts, but very different regarding decisions and performance. In turn, studied municipalities show low, medium, and high EDRM levels. This setting allows us to capture a wide range of causes behind municipal EDRM investment by the institutional analysis (Ostrom 1990).

Second, we connect our qualitative findings with rigorous statistical analysis covering almost all local governments within a country for various years, allowing us to exploit both cross-sectional and time variation to understand local government EDRM decisions for a whole country, something seemingly rare in the literature. We test whether MIAs, SC, and MLG are important for explaining average local government decisions in emergency funds, adaptation, and vulnerability reduction. While MIA and SC factors explain emergency funds better, MLG seems much more decisive in adaptation and vulnerability reduction categories. These findings lead to a more nuanced vision of institutions and EDRM investments in which institutional improvements may lead to compositional changes in EDRM.

Third, we illustrate the importance of findings and a multisystem approach by using our models to simulate the EDRM investments that one would observe in municipalities with altered configurations of MIAs, SC, and MLG.

In the case of Chile, one of the challenges associated with trying to improve these institutional conditions is the sheer scale of the work ahead: our research concludes that the identified conditions related to strong EDRM investments are either weak or nonexistent in the vast majority of local governments. A small fraction of all local governments—only 3.2%—enjoyed above-median scores on all three institutional factors in 2014. Chilean policy makers

[2] The exponential transformation is needed since the counterfactual changes are too large for making the approximation between log points and percentage change to be sufficiently accurate.

have their work cut out for them. As weak as these intuitional conditions may appear, this limitation is also an opportunity because, as our case studies and simulation exercise demonstrated, municipalities that take institutional strengthening seriously and manage to improve their internal organization, coordination mechanisms, transparency, opportunities for participation, and perhaps most importantly, their MLG, have the potential to make tremendous advances in EDRM performance.

Our analysis suggests that there is no institutional silver bullet to fix EDRM underperformance in local governments. Rather, we find that there is a host of institutional factors that seem to matter. Exceptional improvements in performance may materialize when a combination of these factors develop simultaneously.

To strengthen EDRM at the local level, future research would benefit from moving beyond the narrow confirming or testing of the influence of specific individual factors, drivers, or single organizations to an empirical analysis of governance *systems* from a polycentric perspective, supported by mixed methods. Such an approach promises to achieve a deeper understanding about the links, connections, and causal relationships that help to shape human efforts to govern collective goods and services in our societies.

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