



The role of the private sector and citizens in urban climate change adaptation: Evidence from a global assessment of large cities

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ABSTRACT

Expectations of cooperation between local authorities, the private sector, and citizens in climate change adaptation in cities are high because involvement of many actors is seen as critical to success. Scholars and policymakers argue that the private sector could be more efficient than the public authorities in implementing adaptation measures and argue for the need to engage citizens to ensure legitimacy of adaptation and inclusion of locally relevant knowledge. To what extent do cities address the private sector and citizens in their adaptation initiatives? What modes of governance do they use to do this? What kinds of cities are the most likely to address the private sector and citizens? Going beyond the existing case study approaches, this paper answers these questions using a large N data set covering 402 cities around the world. We find that a majority of adaptation initiatives focus exclusively on the public sector and do not address the private sector or citizens. In the cases where they do, the private sector is more often governed through partnerships and participation, whereas citizen participation is relatively rare. Initiatives involving citizens rely more often on a provision of information that encourages citizens to adapt. We find that the more advanced a city is in its adaptation process, the more likely it is to address the private sector than citizens in its initiatives to adapt to climate change. Whereas with partnerships and participation the private sector can influence urban adaptation arrangements at a broader scale, the provision of information allows citizens only to implement individual adaptation measures according to their capacities.

1. Introduction

There is a broad consensus that the private sector and citizens should be involved in urban climate change adaptation, alongside public authorities. The 5th Intergovernmental Panel on Climate Change (IPCC) report states “[L]ocal government and the private sector are increasingly recognized as critical to progress in adaptation” (IPCC, 2014, p. 25). The report’s chapter on urban areas highlights the importance of the engagement of citizens and the private sector but also mentions that citizen participation and private sector involvement has so far been limited in practice (Revi et al., 2014, 580–585). The Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC, 2015) identifies “civil society, the private sector,

financial institutions, cities and other subnational authorities” (p. 19) as crucial actors responding to climate change. Likewise, many national adaptation policy documents stress the role of local authorities, citizens, and the private sector (e.g., Danish Nature Agency, 2012; German Federal Government, 2008; MMM, 2014).

Empirical research on urban adaptation finds surprisingly little active involvement of citizens and the private sector (Hegger et al., 2017; Juhola, 2013; Klein et al., 2017; Lund et al., 2012; Wamsler, 2016; Wamsler and Brink, 2015), with much effort being placed on mainstreaming within the public sector (Widmer, 2018). Even though there are empirical examples of involvement of the private sector and citizens (e.g., Anguelovski and Carmin, 2011; Bedsted and Gram, 2013; Chu, 2016b; Mees et al., 2014), there seems to be a lack of guidance for the

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private sector's and citizens' adaptation (van Kasteren, 2014; Wamsler and Brink, 2015). So far, the involvement of private actors (citizens and the private sector) seems to be limited to the implementation of adaptation measures, while problem analysis and framing of adaptation solutions is dominated by the public authorities (Burton and Mustelin, 2013; Klein et al., 2017; Lund et al., 2012; Mees et al., 2015; Tennekes et al., 2013). Citizens are rarely involved in the problem framing of adaptation (Chu, 2016a; Hegger et al., 2017; Klein et al., 2017; Mees et al., 2015), and their activities are often not intentional adaptation but de-facto adaptation, motivated by factors other than climate change (Wamsler et al., 2016; Wamsler and Brink, 2015).

In terms of what modes of governance are used to steer adaptation activities of the private sector and citizens, the literature is limited. First, most of these studies are single-case, small-n studies, or cross-scale analyses (Araos et al., 2016b; Keskitalo et al., 2012; Swart et al., 2014). The differences between case studies reduce the possibilities for a consistent and comprehensive analysis across cases, and this makes it difficult to arrive at a comprehensive picture of governance of adaptation in urban areas. There are notable exceptions of cross-case adaptation studies (Wamsler and Raggars, 2018) and studies addressing sets of 100–885 cities, but these address predominantly climate change mitigation (Bulkeley et al., 2013; Castán Broto and Bulkeley, 2013; Heidrich et al., 2016) and/or they are not very specific about who is involved in and steered by adaptation measures (Aguiar et al. 2018; Araos et al., 2016a, 2016b; Hunt and Watkiss, 2011; Reckien et al., 2018). Second, there is a dominance of and bias toward studies in developed countries (Bulkeley et al., 2013; Castán Broto and Bulkeley, 2013; Meerow and Mitchell, 2017). There is, thus, a need to complement the existing small-n studies with the analysis of bigger data sets that allow for generalization (Ford et al., 2016; Swart et al., 2014).

In this study, we pose three hypotheses and test them based on the data set of 997 adaptation initiatives in 402 cities¹ across the world, compiled by Araos et al. (2016b), which is to our knowledge the most comprehensive database of its kind. The data include information about each adaptation initiative and the cities' progress in the adaptation policy process. We measure the progress of the cities using the adaptation policy process index (Araos et al., 2016b), and we identify the addressees and mode of governance for each adaptation activity.

2. Hypotheses

Despite the high expectations in policy documents and some encouraging examples in the research literature, several empirical studies have found that cities' engagement with the private sector and citizens is very limited. In the relatively rare cases where such engagement is present, it is most often focused on the implementation of adaptation measures (Hegger et al., 2017; Juhola, 2013; Klein et al., 2017; Lund et al., 2012; Mees et al., 2015; Tennekes et al., 2013; van Kasteren, 2014), rather than involving the private sector and citizens throughout the adaptation policy process. Overall, most adaptation efforts documented by case studies at the city level seem to be focused on institutionalizing adaptation within local governments (Aylett, 2015). Thus, we propose the following hypothesis:

- 1.) So far, most public sector adaptation initiatives focus on the public sector and do not actively steer adaptation activities of the private sector and citizens.

Next, the involvement of citizens and the private sector in adaptation entails more complex considerations than whether and when they are involved. These considerations include questions about the

rationale for involvement and the modes of governance that are being used to address different actors and how this then plays out in terms of responsibilities related to adaptation.

Several arguments have been presented in the literature to support the idea that involvement of the private sector and citizens beyond the fulfillment of legal requirements is important in urban adaptation. This literature provides two broad strands of reasoning, one focusing on market orientation and the other on engagement and participation. First, it is argued that limited capacities of the public sector and the continuing trend of a retreating state can be seen as a reason to form partnerships and shift responsibilities to the private sector and citizens (Geaves and Penning-Rowsell, 2016; Taylor and Harman, 2016; Tompkins and Eakin, 2012; Wamsler, 2016; Wamsler and Brink, 2014). Some economists see private actors as responsible if adaptation is considered to provide a private good (Konrad and Thum, 2014; Mendelsohn, 2006). Second, reasons for engagement and citizen participation include issues, such as legitimacy, inclusion of citizens, and the use of local knowledge. The legitimacy of adaptation may depend on the involvement and participation of a variety of stakeholders and fair consideration of different interests (Adger et al., 2005; Castán Broto and Bulkeley, 2013; Mees et al., 2014). Participation of non-public actors can be seen as a value in itself (Arnstein, 1969; Klein et al., 2017; Mees and Driessen, 2018; O'Hare et al., 2016), and it may enable access to local and tacit knowledge, thus improving implementation and ownership of adaptation initiatives (Boezeman, 2015; Fünfgeld and McEvoy, 2014; Glaas et al., 2010; Wamsler, 2017).

These two different rationales for involving the private sector and citizens have implications on the modes of governance that may be used to encourage involvement. It has become clear from previous studies that citizens and the private sector can be involved in different stages in an adaptation process, and this can happen via different modes of governance (Bulkeley et al., 2013; Castán Broto and Bulkeley, 2013; Kern and Alber, 2008; Klein et al., 2017; Mees et al., 2015, 2014). If the main rationale is economic, it may be most feasible to achieve the desired type of involvement through modes of governance, such as public-private business partnerships or provision of economic incentives. If, on the other hand, the main rationale is engagement, the modes of governance used to encourage involvement need to include different types of participatory processes, including both citizens and the private sector. Considering possible modes of governance juxtaposed with the rationales for the involvement of non-public actors, we hypothesize that:

- 1.) Local authorities use different modes of governance depending on whether they aim to steer citizens' actions or the private sector.

Finally, we are interested in what kinds of cities are the most likely to address the private sector and citizens. It is assumed that cities where the adaptation policy process has advanced the furthest may be more likely to address private actors. The literature includes examples of pilot projects and alternative approaches that strive for a stronger involvement of citizens and the private sector. Examples from the Nordic countries, where cities tend to be rather advanced in their adaptation policy processes, indicate horizontal cooperation and more active involvement of citizens and the private sector, even though many authors point to the limiting influence of existing institutional structures (Klein, 2016; Rauken et al., 2014; Wamsler, 2017). Similarly, Mees et al. (2014) show in Hamburg, Helsinki, and Rotterdam—three cities advanced in their adaptation policy processes—that new alternative approaches to flood risk management entail an increased involvement of private actors. In most cases, however, stakeholder involvement has remained at the early experimentation stage, in both the Global North and the Global South (Anguelovski and Carmin, 2011; Chu, 2016b). In their assessment of the climate change activities (mitigation and adaptation) of 200 European cities, Heidrich et al. (2016) find that the cities focus on their own organizations first before moving on to address

¹ The data are from urban areas larger than 1 million people. For the sake of readability, we use the term "city" for urban areas, as defined in the "Methodology" section, and the related public authorities and administration.

external actors. Hence, we hypothesize that:

- 1.) The more advanced a city is in its adaptation policy process, the more likely it is to address the private sector and citizens in its initiatives to adapt to climate change.

Besides how far the adaptation policy process has progressed in a city, other factors may influence its likelihood to address private actors. One possibility is simply that wealthier cities involve private actors more than others due to their strong capacities to do so. Another is that larger cities have more opportunities to involve the private sector and citizens. Thus, we control for these two factors in our models when analyzing the statistical association between the degree of advancement in the adaptation policy process and the likelihood of a city addressing private actors.

3. Methodology

3.1. Data collection

To test our hypotheses, we used a quantitative data set of urban adaptation planning initiatives assembled through systematic data collection methods presented and analyzed in two previous studies (Araos et al., 2016a, 2016b). The data included 997 adaptation initiatives from 402 urban areas around the world larger than 1 million people, as per the United Nations definition of “urban agglomeration” (UN DESA, 2018). The data were collected from publicly available web-based documents that specifically dealt with adaptation to climate change. These were Municipal Adaptation Plans, Climate Action Plans, and government projects in partnership with non-governmental organizations (NGOs). Due to the logistic constraints of language translation, cities were only included if at least four other cities spoke a common language. Languages included were: English, Spanish, and French (spoken by the data collection team) and Chinese, Arabic, Russian, German, Portuguese, Farsi, Korean, Japanese, Turkish, and Indonesian (using hired translators).

The data collection protocol for the data set in Araos et al. (2016a, 2016b) is as follows: For each city, documents were retrieved using the Google search engine. The first step was to access the municipality's website, then look for climate change planning documents on the website. If no documents were found, then the authors performed a new search using the terms *climate change* and the city's name. The first 50 results were reviewed based on title and page descriptions from Google. Given that the data consist of documents that are predominantly strategic, they do not allow us to examine implementation of these initiatives in detail. Data were collected between January 2 and March 29, 2014, and documents published after this date were excluded. The use of publicly available documents is consistent with other studies' monitoring and tracking adaptation plans (Lesnikowski et al., 2016; Reckien et al., 2014). (For a full description of the data collection protocol and inclusion and exclusion criteria, see Araos et al. (2016a, 2016b)).

A challenge for rigor in comparative adaptation studies is to identify precisely what is being compared (Dupuis and Biesbroek, 2013; Sherman et al., 2016). The Paris Agreement, for example, does not define adaptation with enough clarity to distinguish the concept from other activities that reduce vulnerability, such as disaster risk reduction or the suite of social policies that improve wellbeing in general (Ford and Berrang-Ford, 2015; UNFCCC, 2015). Scholarly efforts to compare adaptation, then, often define climate change adaptation as the activities, policies, or initiatives that are explicitly stated as such (Araos et al., 2016a; Austin et al., 2015; Hughes, 2015; Lesnikowski et al., 2015). Dupuis and Biesbroek (2013) define these as “highly intentional” initiatives because they are expressly designed to deal with the risks of climate change. The data set from Araos et al. (2016b) uses explicit mention of “climate change” as a filter for activities mentioned

in climate change plans. Consistent with this conceptualization of adaptation, this study draws from Dupuis and Biesbroek (2013, p. 1480) to define adaptation policy as:

The process leading to the production of outputs in forms of activities and decisions taken by purposeful public and private actors at different administrative levels and in different sectors, which deal intentionally with climate change impacts and whose outcomes attempt to substantially impact actor groups, sectors, or geographical areas that are vulnerable to climate change.

Data on the population of the cities were retrieved from the data set by Araos et al. (2016b), and data on the country-level gross domestic product (GDP) (ppp) in 2016 were collected from The World Bank's databank (World Bank, 2018). These are included as control variables in our regression models testing hypothesis 3.

3.2. Coding and variables

We coded each adaptation initiative's addressees and mode of governance. We identified three large groups of potential actors: public sector, private sector, and citizens. An actor was considered an addressee if the initiative directly or indirectly assigned an active role to them (i.e., the addressees are encouraged to change their behavior and adapt to climate change). Each initiative had one or more addressee. This meant this variable was not mutually exclusive. The initiative could also be unspecific about the addressee. In this case, the variable was “undetermined” (see Supplementary material 1).

We based our coding of modes of governance on the four categories used by Kern and Alber (2008); Bulkeley and Kern (2006), Castán-Broto and Bulkeley, and Klein et al. (2017). The four categories include governing by regulation, governing by provision of incentives and services, governing through enabling (information, partnership, and participation), and municipal self-governing. However, we consider the categories “governing by provision of incentives and services” and “governing through enabling (information, partnership, and participation)” as too broad for our study.

Whereas the provision of incentives encourages a certain type of behavior or adaptation, the provision of services by the public sector reinforces existing behaviors, which could be a disincentive for adaptation. Whereas partnerships and participation allow for influencing the problem framing and a common development of adaptation solutions, the provision of information offers no opportunity for active participation but gives the recipients the information for the implementation of adaptation measures (Arnstein, 1969; Mees et al., 2015, 2012; Tennekes et al., 2013; Wamsler and Raggers, 2018).

Therefore, we refined the four categories presented above, and we coded our data in six categories: governing by regulation, governing by provision of incentives, governing by provision of services, governing through provision of information, governing through partnerships and participation, and municipal self-governing. Consequently, addressing citizens and the private sector could mean an involvement in adaptation by following legislation; the encouragement to act via incentives and services; an active role in urban adaptation for non-public actors through partnerships and participation; or the enabling and encouragement of individual action by the provision of information. Although all modes of governance could encourage adaptation, the modes differed in the way they involved non-public actors in urban adaptation. In several cases, the description of the activity did not include any further details about how it should be implemented. In these cases, the variable remained “undetermined.” For a detailed description, see Supplementary material 1.

The main independent variable of the regression models testing hypothesis 3 was the adaptation policy process index developed by Araos et al. (2016b). We measured the progress of cities' adaptation policy processes by the *adaptation process index* by Araos et al. (2016b). The cities scored points on the adaptation index by adopting measures such as creating climate projections and vulnerability assessments. The

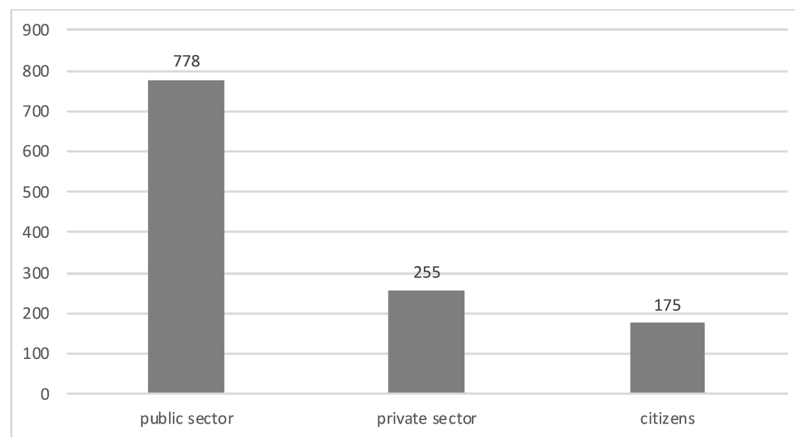


Fig. 1. Number of adaptation initiatives addressing public sector, private sector and citizens.

index measured the presence of (1) climate projections, (2) vulnerability assessments, (3) consideration of multiple sectors, (4) re-assessment of development priorities in the face of climate change, (5) climate change planning documents, (6) consultations and stakeholder engagement, (7) management of barriers and uncertainty, and (8) monitoring and evaluation of adaptation activities (Araos et al., 2016b). The more of these things a city had, the more advanced it was considered in its adaptation policy process.

3.3. Statistical analysis

To analyze hypotheses 1 and 2, we used one and two independent sample chi-squared tests, respectively (Meyers et al., 2013, 645 and 665). For hypothesis 3, we applied different exponential dispersion models depending on the dependent variable. To test the association between the number of initiatives addressing any private actors in a city and the city's process index, we used negative binomial regression models due to the type and distribution of the dependent variable. Negative binomial regression can be used to analyze count variables that have variability different than their mean. In this case, the dependent variable had some overdispersion and variance greater than the mean. The traditional negative binomial regression model was written as $\ln(\mu) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_p x_p$. This meant that a one-unit increase in parameter x had a multiplicative effect of $\exp(\beta)$ on the mean of dependent variable Y (Zwilling, 2013). When analyzing the share of initiatives addressing the private sector or the citizens, we used a generalized linear model with Tweedie distribution (compound Poisson-gamma) and a log link; thus, the model was also an exponential model. The dependent variable had non-negative scale values skewed toward smaller values, and for this we used a distribution that combined properties of continuous and discrete distributions. A detailed description of fitting a Tweedie's compound Poisson model can be found, for instance, in Jørgensen and Paes De Souza (1994). Analyses regarding hypotheses 1 and 2 were conducted at the initiative level ($n = 902$) and analyses regarding hypothesis 3 at the city level ($n = 373$). All analyses were conducted using IBM SPSS.

In these models, the number of initiatives addressing any private actors (private sector and citizens combined) or the share of these initiatives (private sector and citizens separately) from all initiatives was treated as the dependent variable, and the process index of a city was the main independent variable of interest. In addition, we tested whether the association was the same across all values of the process index by using a quadratic term of the independent variable. Our models controlled for the population size of the city and a country-level GDP, used here as a proxy for the wealth of the city. This was to make sure that any association we found between the policy process index and the likelihood of a city to involve its businesses and citizens in adaptation

was genuine and not caused by other factors, such as rich cities or big cities being more able to do more. These analyses were conducted on a city level rather than an initiative level, which was used in the previous analyses.

We excluded initiatives with an “undetermined” addressee. Therefore, 902 of the database's 997 initiatives were considered in our detailed analysis. In addition, we excluded some cities because of missing data. Therefore, our detailed analysis was based on 373 out of 402 cities.

4. Results and discussion

4.1. Involvement of different actors

Given the results of previous studies that showed the limited involvement of citizens and the private sector in urban adaptation, we hypothesized, first, that so far most public sector adaptation initiatives focused on the public sector itself and did not actively steer adaptation activities of the private sector and citizens.

Our results confirmed this hypothesis. Fig. 1 shows the distribution of actors addressed by the adaptation activities. We used a one sample chi-squared test to confirm that the number of initiatives addressing the public sector is significantly higher than the number of initiatives addressing the private sector or citizens, when equal distribution is expected. The value of the chi-squared test is 474,186, which is highly significant in this case ($df = 1$, $n = 902$).²

This result is logical because it is easiest for the public sector to control its own activities. However, it conflicts with the high expectations of increasing private involvement. However, there are several initiatives that are aimed at the private sector or citizens, implying that the cities are motivated to involve private actors in adaptation.

4.2. Modes of governance for steering different actors

To test our second hypothesis—whether cities use different modes of governance to steer different addressees—we used a two sample chi-squared test for each type of addressee separately. We compared initiatives addressing the private sector or citizens to each other and initiatives addressing the public sector to all other initiatives. As presented in Table 1, initiatives addressing the private sector used more governing through participation and partnership (ϕ 0.113), a little more governing by regulation (ϕ 0.198), and less governing through information compared to initiatives addressing citizens but not the private sector. Equally, initiatives addressing citizens used more

² The total number of addressed actors ($n = 1,207$) is bigger than the number of adaptation activities because one activity can have more than one addressee.

Table 1
Results of the two sample chi-squared test of independence.

Addressee	Mode of governance	Pearsons chi-square			Phi		N
		Value	df	p	Value	Approx. Sig.	
Public sector (compared to all other initiatives)	Governing by regulation	10.102	1	0.001	−0.106	0.001	902
	Municipal self-governing	192.181	1	0.000	0.462	0.000	902
	Governing by provision of services	3.031	1	0.082	−0.058	0.082	902
	Governing by provision of incentives	101.994	1	0.000	−0.336	0.000	902
	Governing through information	67.665	1	0.000	−0.274	0.000	902
	Governing through participation and partnership	3.934	1	0.047	−0.066	0.047	902
Private sector (compared to initiatives addressing citizens, but not the private sector)	Governing by regulation	12.143	1	0.000	0.198	0.000	309
	Municipal self-governing	.					309
	Governing by provision of services	1.124	1	0.289	−0.06	0.289	309
	Governing by provision of incentives	3.171	1	0.075	0.101	0.075	309
	Governing through information	36.976	1	0.000	−0.346	0.000	309
	Governing through participation and partnership	3.975	1	0.046	0.113	0.046	309
Citizens (compared to initiatives addressing private sector, but not the citizens)	Governing by regulation	1.675	1	0.196	0.074	0.196	309
	Municipal self-governing	.					309
	Governing by provision of services	0.185	1	0.667	−0.024	0.667	309
	Governing by provision of incentives	0.05	1	0.823	−0.013	0.823	309
	Governing through information	37.489	1	0.000	0.348	0.000	309
	Governing through participation and partnership	42.385	1	0.000	−0.37	0.000	309

governing through information (phi 0.348) and less governing through participation and partnership (phi -0.370) compared to initiatives addressing the private sector but not citizens. Initiatives addressing the public sector used more municipal self-governing (phi 0.462), a little less governing by regulation (phi -0.106), governing through participation and partnership (phi -0.066), somewhat less governing through information (phi -0.274), and governing through provision of incentives (phi -0.336) than initiatives addressing only private actors (private sector or citizens).³

In Fig. 2, we present how many initiatives related to certain modes of governance were addressed to each actor. The results are presented as percentages of modes of governance for each addressee group. It must be recognized that most of the initiatives address the public sector, and initiatives addressing the private sector or citizens are less common (see Section 4.1). The results confirm our hypothesis that local authorities steer citizens and the private sector differently. When steering the private sector, governing through partnerships and participation was the most popular mode. The most popular mode of governance when steering citizens, instead, was governing through provision of information. The differences in the use of other modes of governance were less pronounced. Governing by provision of services was overall used very little. Governing by regulation and by provision of incentives were used slightly more when steering the private sector.

The literature already shows that citizens and the private sector can be involved through the use of different modes of governance (Bulkeley et al., 2013; Castán Broto and Bulkeley, 2013; Kern and Alber, 2008; Klein et al., 2017; Mees et al., 2015, 2014). We can analyze what modes of governance are used to involve different actors, but no explicit conclusions about why cities want to involve private actors can be made based on our data and analysis. Although modes of governance cannot directly provide an answer to the rationales of private actors' involvement, the modes can be associated with different intentions (Klein et al., 2017).

If the desired outcomes of private actor involvement include access to local and tacit knowledge (Boezeman, 2015; Fünfgeld and McEvoy,

2014; Glaas et al., 2010; Wamsler, 2017) and increasing the legitimacy of adaptation (Adger et al., 2005; Castán Broto and Bulkeley, 2013; Mees et al., 2014), it is logical that governance through participation and partnership is needed. It gives other actors the opportunity to influence policy goals and priorities (Vogel and Henstra, 2015). In our results, this mode of governance is used especially with the private sector and less with citizens. This suggests that the private sector has more access to influence policy goals and priorities than citizens do, leading to power imbalances. Also, this can result in knowledge from the private sector being considered more than the knowledge of citizens. The citizens are steered mainly through the provision of information, which is a more one-way process and a top-down form of governance. The local authorities give information to citizens, who are then expected to use that information to implement adaptation (Arnstein, 1969; Mees et al., 2012; Tennekes et al., 2013).

If the intention is to shift responsibility to the private sector, due to limited resources of the public sector (Geaves and Penning-Rowsell, 2016; Taylor and Harman, 2016; Wamsler, 2016; Wamsler and Brink, 2014), governance through participation and partnership might be useful, as it can mean support for actions led by some other actors (Castán Broto and Bulkeley, 2013). However, this is not an unproblematic mode of governance. Several authors ask critically about how shifting responsibilities to non-state actors can exacerbate inequalities and cause vulnerabilities (Davoudi, 2014; Felli and Castree, 2012; Meerow and Mitchell, 2017; O'Hare et al., 2016; Schlosberg et al., 2017; Webber, 2016).

4.3. Adaptation process and involvement of private actors

Our third hypothesis stated that the more advanced a city is in its adaptation policy process, the more probable it is that the public sector will encourage the private sector and citizens to adapt to climate change. To test this assumption, we performed three different analyses. First, we tested whether the total number of initiatives addressing citizens and the private sector depends on the adaptation process index. In the second and third analyses, we tested whether the share of initiatives addressing the private sector and citizens changes depending on the adaptation process index. Descriptive statistics of the variables used in the analyses are presented in Table 2.

The negative binomial regression analysis was conducted in three parts to see whether the association changes when adding new

³ As a robustness check, we repeated these analyses without initiatives of New York with similar results. This robustness check was done due to the city's large amount of initiatives compared to any other city. We wanted to be sure that no practices only typical to New York would dominate the results.

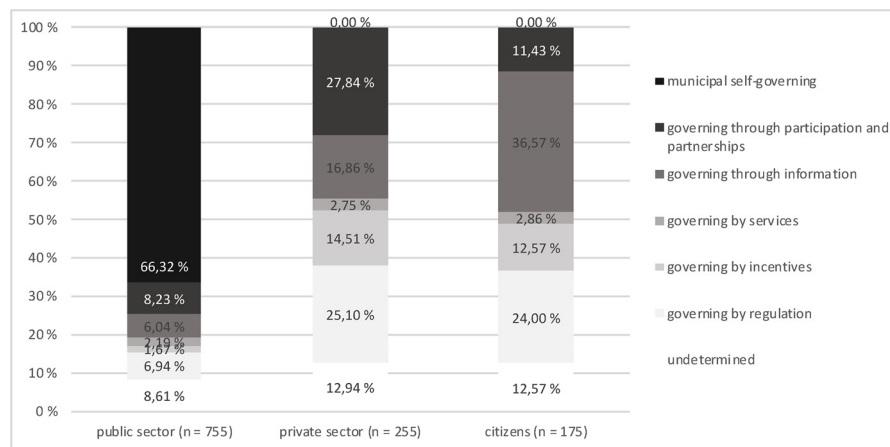


Fig. 2. Modes of governance for each group of addressees.

Table 2
Variables in the regression models.

	N	Minimum	Maximum	Mean	Standard deviation
Number of initiatives addressing private actors	373	0	24	0.53	2.367
Share of initiatives addressing private sector (out of all initiatives)	63	0	100	17.912	22.159
Share of initiatives addressing citizens (out of all initiatives)	63	0	100	16.222	19.5
Process index	373	0	8	1.55	2.456
Country level GDP (per capita in thousands)	373	0.8008	87.8556	2.2448	18.1535
Population (100 000)	373	10.0159	369.3278	31.2744914	36.0779515

Table 3
Parameter estimates and goodness of fit for negative binomial regression models.

Parameter	Model 1				Model 2				Model 3			
	B	Std. Error	p	exp(B)	B	Std. Error	p	exp(B)	B	Std. Error	p	exp(B)
Intercept	−4.180	0.344	0.000	0.015	−8.345	1.524	0.000	0.000	−9.068	1.613	0.000	0.000
Process index	0.789	0.053	0.000	2.202	2.618	0.595	0.000	13.703	2.752	0.641	0.000	15.672
Process index squared					−0.173	0.054	0.001	0.841	−0.187	0.059	0.001	0.829
GDP (in thousands)									0.018	0.010	0.077	1.019
Population (100 000)									−0.004	0.005	0.436	0.996
(Scale)	1.000				1.000				1.000			
Goodness of fit:	Value	df	value/df		Value	df	value/df		Value	df	value/df	
Deviance	151.447	371	0.408		130.157	370	0.352		123.728	368	0.336	
Pearson chi-square	260.35	371	0.702		167.227	370	0.452		154.164	368	0.419	
Log Likelihood	−169.142				−158.498				−155.283			
AIC	342.285				322.995				320.566			
BIC	350.128				334.76				340.174			

variables to the model. Model results are presented in Table 3. Our first analysis suggests that the number of initiatives addressing private actors indeed rises as a function of the city's process index.⁴ However, this association did not hold true for all values of the process index. Parameter estimates for the quadratic term in models 2 and 3 suggest that the positive association between process index and the number of initiatives addressing private actors turns to a decline when a certain value is reached. This indicates at least that very high process index scores do not necessarily lead to an additive effect to a city's tendency to encourage private actors compared to cities with medium-high process index scores. Both associations stayed significant after accounting for population size and GDP, but the model itself did not seem to fit any better after including these controls. Overall, the model fit was further analyzed with deviance residuals of the full model, which showed a

⁴ We also ran the analyses for private sector and citizens separately, with almost identical results.

reasonably good fit to the data (see Supplementary material 2).

The association is further demonstrated in Fig. 3, where predicted values of initiatives addressing private actors are plotted against the process index. The predicted values seemed to take more of a convex form, but the concave regression line, and thus the quadratic process index term, also captured the declining trend at the end of the scale. Fig. 3 indicates that the number of initiatives addressing private actors did not increase in the lowest levels of the process index.

This analysis confirmed our third hypothesis for both the private sector and citizens. The more advanced a city's adaptation process is (i.e., the higher the city's process index), the more likely its adaptation activities address the private sector and citizens. These global-scale findings are in line with the results for 200 European cities by Heidrich et al. (2016). It is, however, notable that there is no linear relation between process index and the involvement of citizens and the private sector. There seems to be a threshold at a process index of 4 that must be crossed before cities reach out to other actors beyond their own

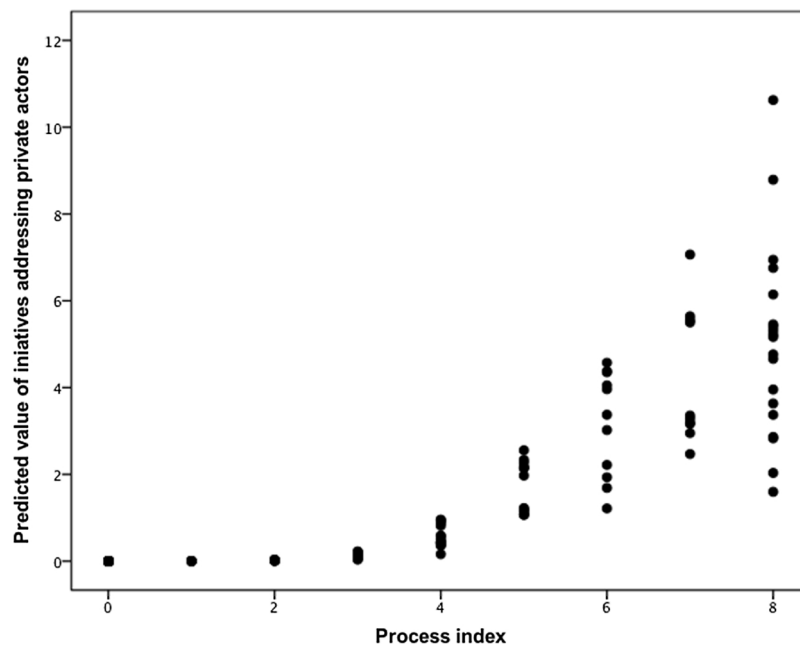


Fig. 3. The association between a city's process index and the number of initiatives addressing private actors.

organizations. We performed the same type of analysis for all initiatives (i.e., independent of the addressees) and found similar results. This means that the number of initiatives addressing citizens and the private sector changes in a similar way as the overall number of initiatives depending on the process index.

The results of our second analysis additionally show a connection between the share of initiatives addressing the private sector and the process index (see Table 4 and Fig. 4). First, the share rose with a growing process index, but the variation increased at high numbers of the process index while the average share of initiatives addressing the private sector seemed to decline. Up to a process index of 6, cities increased the proportion of initiatives addressing the private sector. However, the index explained only a small part of the variance of the share. This means that although the results support and strengthen the results of the first analysis, it appears that the progress in adaptation policy (represented the process index) is not the only, nor the most important, explanatory factor for the public sector to address the private sector.

Our third analysis on the share of initiatives addressing citizens shows a similar dependency of the share of initiatives from the process index as the second analysis. However, having added population and GDP as control variables, the results were not statistically significant. This means that we cannot confirm that an advanced adaptation policy process would affect how actively cities address citizens in their

adaptation initiatives.

Overall, the relation between a city's adaptation progress and private actors' involvement provides a potential explanation for the discrepancy that can be observed in the literature. On one hand, examples of citizen involvement and cooperation with the private sector at different stages of the adaptation process are often chosen from frontrunner cities (e.g., Anguelovski and Carmin, 2011; Mees et al., 2014; Woodruff, 2018). This focus on successful initiatives gives the impression that citizens are involved in the adaptation process actively, while this may not be the case for the majority of cities or even valid citywide in the frontrunner cities. On the other hand, studies finding that cities' adaptation is mostly focused on the public sector and involves the private sector and citizens only marginally are based on broader data sets (Hegger et al., 2017; van Kasteren, 2014; Wamsler, 2016; Wamsler and Brink, 2015) or represent cities with less-pronounced adaptation activities (Juhola, 2013; Klein, 2016; Lund et al., 2012).

The second and third analyses raise further questions. First, our analysis shows a rather weak influence of the process index on the private sector being addressed. This means that, although progress in adaptation increases the number of initiatives addressing the private sector, there are other explanatory factors that are not included in our model. Some of these issues, such as the influence of administrative traditions on adaptation, have become of interest lately (Biesbroek

Table 4

The effect of process index on the share of initiatives addressing private sector in a city: parameter estimates and goodness of fit for tweedie models.

Parameter	Model 1			Model 2			Model 3		
	B	Std. Error	p	B	Std. Error	p	B	Std. Error	p
Intercept	1.994	0.617	0.001	−2.545	2.310	0.271	−4.401	2.767	0.112
Process index	0.132	0.100	0.186	1.868	0.838	0.026	2.333	0.952	0.014
Process index squared				−0.151	0.071	0.034	−0.192	0.081	0.018
GDP (in thousands)							0.019	0.009	0.043
Population (100 000)							0.000	0.000	0.650
Goodness of fit:									
Deviance	414.652			378.014			349.942		
df	56.000			55.000			52.000		
Value of deviance/df	7.404			6.873			6.730		
AIC	390.402			387.182			386.944		

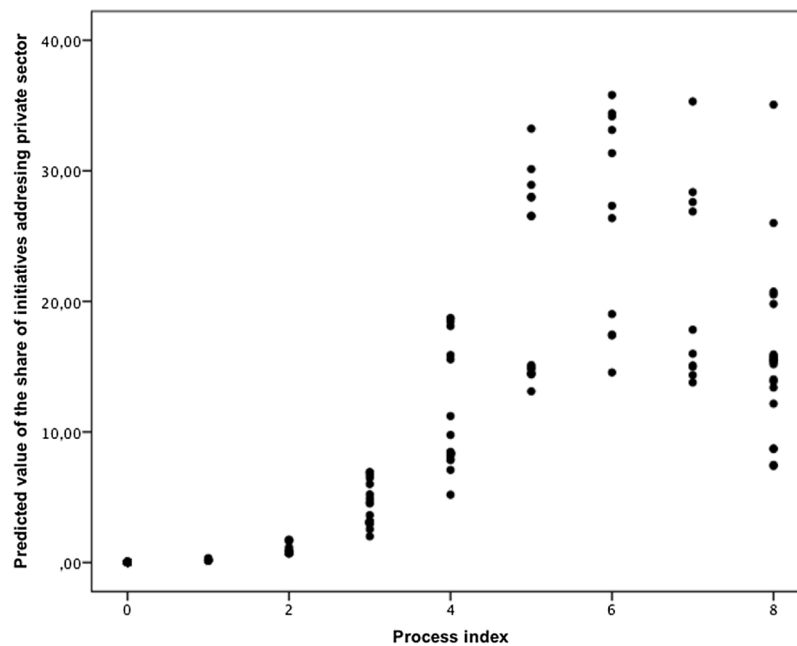


Fig. 4. The association between a city's process index and the share of initiatives addressing private sector.

et al., 2018, Klein and Juhola, 2018). Second, our results show that there is no statistically significant connection between addressing citizens and the process index, a connection that can be observed with the private sector. Given that the private sector is steered more overall, and this is likely to increase as a city progresses on adaptation, it appears that the involvement of the private sector is generally stronger than citizens' involvement. Thus, we can critically ask what makes it more attractive to involve and address the private sector than citizens (Fieldman, 2011; Whitehead, 2013) because theoretical considerations support the active involvement of both groups.

5. Conclusions

We have reviewed adaptation activities of 402 cities with more than 1 million inhabitants globally to identify the extent to which cities address their citizens and the private sector. We also analyzed the modes of governance they use to steer different actors and the potential association between a city's progress in adaptation and the engagement of the private sector and citizens. These findings support previous case study work and studies in smaller cities, which show focus predominantly on adaptation of the public sector, often through mainstreaming (Runhaar et al., 2018), and less on encouraging the adaptation or changing the behavior of private actors.

Our study provides an overview of the current state of modes of governance used in adaptation globally, something that the literature so far has lacked. This approach does not allow us to examine why these modes are used, whether their implementation is successful, or how effective they are. What appears clear is that when it comes to governing adaptation, regulation is not a very common mode across the board, with participation and partnerships with the private sector and provision of information to citizens being most popular outside of municipal self-governance. This could be because of the early stage of adaptation (see e.g., Keskitalo et al., 2016), suggesting that harder instruments may follow as the governance of the issue becomes more mature. Alternatively, this use of softer modes may be a sign of shifting responsibilities away from the state/public sector in order to distribute the cost and responsibilities of preparing for climate change to various actors. Naturally, there is a further need to identify policy measures that are being used and how they continue to develop (Wamsler and Raggars, 2018).

This use of softer instruments has implications for policy. The differences in addressing the private sector and citizens can have impacts on the justice and fairness of adaptation when implemented (Chu, 2016a; Mees et al., 2015; Schlosberg et al., 2017). The private sector can influence urban adaptation arrangements at a broader scale through engaging in partnerships and participation, and the provision of information allows citizens only to implement individual adaptation measures according to their capacities. This shifting of responsibilities to non-state actors can exacerbate inequalities and cause vulnerabilities (Davoudi, 2014; Felli and Castree, 2012; Meerow and Mitchell, 2017; O'Hare et al., 2016; Schlosberg et al., 2017; Wamsler and Brink, 2018), which run counter to adaptation objectives. Thus, future research should address the questions regarding the reasons and rationales for the chosen modes of governance.

Based on our findings, it appears that there is a link between a city's progress in its adaptation process and addressing citizens and the private sector, slightly favoring the private sector. This potentially explains the disconnect between empirical studies that find little involvement of private actors and case studies illustrating an involvement and participation of private actors. Case studies in cities with a high process index (e.g., Hamburg 6 on a scale from 0 to 8; Helsinki 8) have a higher chance of reporting the involvement of citizens and the private sector than in cities with a low process index, and scholars looking to analyze such initiatives are likely to gravitate toward the advanced cities where the initiatives are found, steering away from negative cases. A further potential implication of this finding is that if more cities around the world make progress on their adaptation processes over time, it may be that, consequently, the involvement of citizens and the private sector in urban adaptation will increase.

As our results show, the share of initiatives addressing the private sector seems to increase as the adaptation policy process advances (up to a process index value of 6), whereas we could not find a similar significant relationship for citizens. In addition, it is remarkable that there are more initiatives addressing the private sector than addressing citizens; thus, the private sector has via partnerships and participation a stronger role in shaping urban adaptation. This could further be analyzed by assessing differences between cities on different continents or comparing developing country cities with those in developed countries or by focusing on the division of steering between actors to further understand how and why the private sector may be favored more over

citizens. This would inform the debate about the relationship between the theoretical considerations and practical implications of a stronger involvement of citizens and the private sector in urban adaptation.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.gloenvcha.2018.09.012>.

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