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Unpacking the heterogeneity of climate city networks

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ABSTRACT

In recent decades, climate city networks, understood as formalized subnational governance networks that have climate change as their focus, have emerged, linking cities to the global climate governance regime and helping them to take climate action locally. Such city networks are considered an essential aspect of urban climate policy and governance. Scholarship on climate city networks has illustrated that such networks can no longer be understood as homogenous groups of organizations; rather, they show heterogeneity in how they seek to attract and engage with member cities. In this article, we unpack this heterogeneity and interrogate the various ways in which climate city networks attract and engage with their members. We are particularly interested in understanding what typifies climate city networks with an active member base. In studying 22 real-world climate city networks, we uncover five distinct types of networks with an active member base. The typology illustrates the rich, but bounded, variety of climate city networks, and helps to clarify how climate city networks can be effective in encouraging their member cities to take local climate action.

1. Introduction

Climate city networks, understood as formalized subnational governance networks that have climate change as their focus, emerged in the 1980s in response to weak national political responses and the need for on-the-ground action to mitigate climate change (Acuto & Rayner, 2016; Gordon, 2016). These city networks have been rapidly embraced by urban scholars as an essential part of urban policy and governance, and they have repeatedly featured on the pages of *Cities* (e.g., Dent et al., 2016; Klopp & Petretta, 2017; Stren & Friendly, 2019; van der Heijden, 2016). Over time, climate city networks have undergone several waves of development, expanding from the mitigation-focused networks of North America and Europe in the 1990s to the global networks focused on climate adaptation of the 2000s and beyond (Bulkeley et al., 2014; Castán Broto, 2017). Initially, in the 1990s, these networks supported their member cities in taking local climate action: 'municipal voluntarism'. By the 2000s, the focus of the networks had shifted to promoting climate action as an integral part of urban development and economic growth: 'strategic urbanism' (Bulkeley & Betsill, 2013; Gordon, 2018). Since their inception, climate city networks have grown rapidly in number. They now represent well over 25% of the global urban population, making them central players in the global climate governance regime (Bulkeley, 2011; Gordon & Johnson, 2018; Lee, 2018; Lee & Jung, 2018; van der Heijden, 2018a).

As climate city networks expand, researchers bring new questions to bear on their role in urban climate governance. Such questions contribute to traditional network governance theories (Jones et al., 1997; Kickert et al., 1997) and emerging critical urban theory (Bulkeley et al., 2015; Castán Broto & Robin, 2020). Early themes in the literature have addressed the possibility that city networks can transfer experiences and knowledge from 'leader' to 'follower' cities, can give cities a voice in international climate governance forums, and can stimulate experiments in urban climate action across cities (Bulkeley, 2005; Kern & Bulkeley, 2009; Kern & Mol, 2013; Wurzel, Moulton, et al., 2019). In sum, the early literature was largely interested in understanding the variety of services that city networks provide.

In the last few years, increasing attention has been given to the functional differences between, and among, climate city networks, including the ways in which cities within these networks gain access to, and use, resources and knowledge (Busch, 2016). For example, in their survey of 170 city networks (not limited to climate-related networks), Acuto and Rayner (2016) found considerable diversity in their form, focus, size and coverage. Bansard et al. (2017) compared 13 climate city networks in terms of geographical distribution, central players, mitigation ambition and monitoring provisions. They also concluded that there was considerable functional differentiation among climate city

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networks, and characterized them as a poorly understood 'heterogeneous phenomenon' (Bansard et al., 2017, p. 242) in global climate governance. Gordon (2018) pointed out that some climate city networks are initiated by cities while others are started by other types of actors. Haupt and Coppola (2019) indicated, finally, that some networks are 'exclusive elite networks', open to a limited number of cities, while others are 'very inclusive mass networks', open to almost all cities.

In what follows, we build on and contribute to this growing literature that recognizes the increasing complexity of climate city networks and their role in global climate governance (Bansard et al., 2017; Davidson et al., 2019; Gordon, 2018; Nielsen & Papin, 2020). Within this complexity, we are interested in understanding why some climate city networks have been able to attract an active member base, while others have not (Bellinson, 2018; Kern & Bulkeley, 2009; van der Heijden, 2018b). In short, we take a closer look at the efficacy of climate city networks (where efficacy is defined as achieving climate action on the ground, which is explained in more detail in what follows), acknowledging that efficacy is but one of many aims of the large number of climate city networks around the globe. Our specific aim is to understand what typifies climate city networks with an active member base. Arguably, for climate city networks that aim for efficacy, an active membership base is vital to ensuring their continuing relevance through concrete programmes and activities (Coglianese & Nash, 2014; Fransen & Burgoon, 2014). In this article we therefore ask the question: what typifies climate city networks with an active member base?

To answer this question, we apply qualitative comparative analysis (QCA) logic and tools to a set of 22 climate city networks to gain a better understanding of the types of climate city networks that have an active member base. QCA allows us to unpack these networks as configurations of conditions relevant to attracting participants and, on this basis, to work towards an evidence-based typology of the subset of climate city networks with an active member base; we explain this further below (Fiss, 2011). We identify horizontal and decentralized climate city networks, targeting global and regional leader cities, previously reported in the literature (Kern & Bulkeley, 2009). We also find networks with a national scope, as identified by Acuto and Rayner (2016), and networks initiated by non-city organizations, as noted by Gordon (2018), with centralized governance structures. We discuss the relevance of this typology, particularly the way in which it helps us to rethink how climate city networks can link cities to the climate regime. We conclude with the implications of our findings and ideas for future research. In the remainder of this article, we first elaborate on the importance of differentiating between climate city networks. We then outline the QCA methodology used for our analysis, before presenting our empirical results and our typology of climate city networks.

2. Conceptual framework

As pointed out in the introduction, the differentiation of climate city networks has received increasing attention in recent years, as their importance as a transnational mode of global climate governance has been realized. Attention has also recently turned towards understanding what this differentiation implies for the success of climate city networks. It is generally accepted that climate city networks influence local climate governance by providing services to member cities through activities and programmes for capacity building, support for project implementation, and recognition or certification of climate actions (Bellinson, 2018; Harman et al., 2015; Kern & Bulkeley, 2009). However, as Lee and Jung (2018) found, the reality is more nuanced than such a principal–agent theory; while the functions of a network (such as information sharing, lobbying, and funding) matter for its level of activity and survival, cities choose climate city networks based on their priorities, purposes, and resources. Furthermore, cities themselves have evolved by integrating climate change, together with climate city networks, strategically into their urban development processes (Bulkeley & Betsill, 2013), which also expands the number of actors bringing resources and agendas into these processes (Gordon, 2018). Following these insights, questions have been raised about how non-city organizations (such as NGOs and philanthropists) affect this 'new' mode of governance, and about the different motivations that lead climate city networks and cities to engage with each other. For some city networks and their members, the motivation is to accelerate climate action 'on the ground', and they use status, finance, information, and informal means to achieve their ends. For other climate city networks and their members, the motivation is to achieve value-driven ends, such as inclusiveness, democracy, and heightened sensitivity to contextual and cultural conditions (Davidson et al., 2019; Nielsen & Papin, 2020).

In the light of these findings, we further unpack the heterogeneity of action-focused climate city networks. We do so by seeking to understand what distinguishes climate city networks with high member engagement from those with low member engagement, and whether there are multiple types of functional networks with an active member base. In short, we use membership activity as a proxy for the efficacy of climate city networks, conceptualizing efficacy as the ability of a city network to achieve its goals through the cities that participate in it (thus, we do not precisely ask how effective or efficient such a network is, but merely seek to understand if there is an observable pattern or difference between networks with an active member base and those with a passive member base – see, further, Ansell & Gash, 2008; Coglianese & Nash, 2009). In doing so, this research project is inspired by 'club theory' debates in the voluntary programme literature (Potoski & Prakash, 2009; Sandler & Tschirhart, 1997) and in doing so, it follows earlier applications of this theory to climate city networks (Dolšak & Prakash, 2017; Green, 2017).

The club theory holds that initiatives and organizations such as climate city networks can be conceptualized as clubs that provide exclusive rewards to their members, but that also set club-entry and participation criteria for their members and that enforce these criteria to some extent (van der Heijden, 2017). A central question that dominates these club theory debates is whether and how voluntary programmes attract active participants – after all, with a passive member base a voluntary programme is unlikely to achieve its aims. Arguably, the same reasoning holds for climate city networks: ideally, the member cities of a climate city network actively contribute to achieving its goals. When reviewing the climate city network literature, it becomes clear that (indeed) some networks have a more active member base than others (Kern & Alber, 2009; Kern & Bulkeley, 2009). We hypothesize that functional differences may explain the differences in activity levels. We also hypothesize that a bounded set of functional differences between climate city networks can be used to identify the characteristics of networks with high and low levels of member engagement. This, in turn, provides us with a basis for identifying types of functional climate city networks according to the member base activity.

To examine this in greater detail, we consider a set of (probably interacting) network conditions that can help to explain member engagement, and the different pathways and strategies used by climate city networks to achieve such activity. From an analysis of the broader climate city network literature we identified five conditions that are repeatedly mentioned as influencing the capacity of climate city networks to attract members and ensure they are active within the network (Acuto et al., 2017; Bansard et al., 2017; Bouteligier, 2013; Kern & Bulkeley, 2009). The first condition is the *geographical orientation* (*GO*) of the climate city network, which could range from cities within a country to cities in different countries. Cities within the same national border are commonly assumed to face comparable political and economic contexts, making it easier for a network of such cities to provide tailor-made support and programmes, while allowing for more frequent contact and engagement with local issues (Acuto et al., 2017; Lee & Jung, 2018). In contrast, international networks are thought to hold greater prestige for their members, to have a greater capability for connecting with other international actors, and to enable participating cities to learn about climate action from all over the world (Hakelberg, 2014; Lee & Koski, 2014).

The second condition is having a *multi-tiered structure* (*MT*). Climate city networks often have a tiered structure. Lower tiers (effectively sub-networks) may specialize in thematic or geographical issues that are relevant for sub-groups of members, 'offering international coverage but also concrete sub-coalitions' (Acuto & Rayner, 2016, p. 1161). However, a network with sub-networks may seem overly complicated to members, preventing them from finding programmes beneficial to them and thus hindering member engagement. It has also been observed that active engagement, particularly in thematically organized sub-networks, may be undermined by differences between members in terms of, for example, capacity, size, context, or strategy (Capello, 2000; Kern & Mol, 2013).

The third condition affecting the member base concerns the *initiator* (*IN*) of the climate city network. In addition to cities, a diversity of non-city organizations can be involved in the development of a climate city network. These non-city organizations include multilateral organizations and private entities such as NGOs, philanthropic organizations, and for-profit organizations (Gordon, 2018). The kind of organization involved at the start of a network can determine the goal and motivation for (ongoing) membership. For instance, climate city networks initiated by cities may provide an intrinsic motivation (or 'moral duty') for member cities to engage actively with each other. Alternatively, climate city networks established by 'outsider' organizations may have access to the external stimuli and resources necessary to ensure an active member base – illustrative examples are the Rockefeller Foundation, which established 100 Resilient Cities (100RC), or the NGO Adapt-Chile that established Red Chilena de Municipios ante el Cambio Climático (REDMUNICC) (Acuto et al., 2017; Acuto & Rayner, 2016; Davidson et al., 2019; Gordon, 2018; Gordon & Acuto, 2015). One of the challenges that such an 'outsider' organization brings is the risk of the discontinuation of the climate city network if it terminates its support (Nielsen & Papin, 2020).

The fourth condition is the existence of *permanent strategic partnerships* (*PS*) between a climate city network and a broad range of actors. Such partnerships are seen as necessary for the legitimacy and long-term survival of a network (Acuto et al., 2017) – although some argue that they may have the opposite effect (Pattberg, 2010). Partnerships with non-city organizations have been found to be relevant for leading international climate city networks (Davidson et al., 2019). It remains unclear, however, whether permanent partnerships have a more desirable impact on member engagement than temporary or ad hoc ones (Bäckstrand, 2008; Hoffmann, 2011).

The fifth and final condition for member engagement that we identified is *membership diversity* (*MD*) within the climate city network. Many climate city networks are open to a wide variety of cities, and some even allow non-cities to become members ('open membership'). However, some climate city networks restrict their membership to cities that meet specific characteristics ('targeted membership'). There is something to say for both approaches in relation to active member engagement (Haupt & Coppola, 2019; Nielsen & Papin, 2020). While an open criterion could provide many cities and other organizations with access to a diversity of resources, a targeted membership could provide a better focus for the members; it is not clear, ex ante, which of these incentives is more likely to promote more active member engagement (Keiner & Kim, 2007; Smith, 2011).

We use these five conditions as a basis for exploring how the interaction between them (conjunctural causation) may explain high member engagement across a number of climate city networks, and whether there are one or multiple sets of conditions that relate to high member engagement ('equifinality').

3. Methodology

To gain a better understanding of whether and how the five identified conditions relate to and may help to explain member engagement, we carry out a crisp-set qualitative comparative analysis (csQCA) of data obtained from 22 climate city networks. QCA traces patterns of association between the conditions and the outcomes of interest (for an earlier application of QCA in *Cities* see Ruhlandt et al., 2020). The 'crisp-set' qualifier means the conditions used are well-defined sets of qualitative conditions (rather than fuzzy sets for which it is not always clear whether an element is part of a set).

Summarizing from Schneider and Wagemann (2012), QCA is a method based on set theory and Boolean algebra that locates observations within the potential combinations of the conditions used. These combinations are sets related to the outcome within the dataset analysed. Through a systematic process of logic simplification, patterns linking the sets of conditions to the outcome are identified and can be assessed in terms of their coverage (percentage of relevant observations included in a configuration) and consistency (whether observations contradict a configuration) in the observations. The result is a systematic process that links not only simple conditions but also their interactions ('conjunctural causation') with a given outcome, keeping the qualitative nature despite using seemingly simple conditions. Because of its set theory base, different configurations of conditions can (theoretically) lead to the same outcome ('equifinality'). The broader literature on climate city networks indicates that it is likely that conditions interact within a climate city network, and that different combinations of conditions may equally lead to an active member base (Bulkeley, 2010), which makes QCA an appropriate methodology for exploring these configurations.

Our application of QCA is theory-driven. That is, the five conditions and the outcome of interest all have their basis in the broader urban climate governance literature and theories. This literature is explicit that the outcome of interest (an active member base) is likely to be the result of interacting conditions (conjunctural causation), and it indicates that different pathways of interacting conditions may lead to the outcome of interest (equifinality). In this manner, we apply QCA not 'merely' to test the explanatory power of the individual theories from which we have distilled our conditions, but rather to explore how these theories build on and reinforce each other. This is a conventional approach when using QCA for theory development (Berg-Schlosser et al., 2009; van der Heijden, 2020). The fundamentals and background of QCA are well explained and documented in a series of textbooks and applications (Ragin, 2008; Ragin & Rihoux, 2009; Schneider & Wagemann, 2012; van der Heijden, 2017). In this section, the QCA process will be simplified to the three key steps set out in further detail below (for more detail on the approach, see Supplementary Materials): data collection and preparation, test for necessary conditions and test for sufficient conditions.

3.1. Data collection and preparation

We identified a starting sample of 64 climate city networks based on a search of existing studies (Acuto & Ghojeh, 2019; Bansard et al., 2017; Bouteligier, 2010; Lee & Jung, 2018; Lusk & Gunkel, 2018), conferences and online materials (see Supplementary Materials for details). Our sample was limited to climate city networks with information in English or Spanish for which we could find public indicators of engagement. We consider our sample to have a broad enough variety of types of climate city networks for csQCA to draw conclusions (Schneider & Wagemann, 2012). Information on the sample of climate city networks was extracted from their websites and public reports using the following coding of the five network conditions:

- *GO*: International scope is coded as '1'; national scope as '0'.
- *MT*: A multi-tiered structure with the presence of sub-networks is coded as '1'; absence of sub-networks as '0'.
- *IN*: A non-city organization as the original organization establishing the network is coded as '1'; a city as the original organization as '0'.

- *PS*: A permanent partnership with non-city organizations is coded as '1'; a temporary link or no link at all as '0'.
- *MD*: Open membership is coded as '1'; targeted membership as '0'.

We also coded member engagement in the climate city network (the outcome of interest) as high-level engagement (coded as '1') or low-level engagement ('0'). High-level member engagement was defined to mean that 35% or more of the members of the climate city network were actively engaged in the activities of that network. We searched public indicators that allowed us to estimate the percentage of members that participated in a given programme. Public indicators of engagement have limitations, such as being self-reported and missing informal and unreported interactions. However, our analysis only required us to distinguish between active and inactive climate city networks, and this was clear in most cases. If the conclusion on the level of activity was not clear, further reviews of the network's website and reports were carried out to distinguish between active and inactive networks. The level of engagement was determined by scanning the website and public reports of each network to gain insight into how active the members were in the various programmes and activities organized (see Supplementary Materials for details).

The set theory foundation of QCA means that it uses numerical symbols, but it remains a qualitative method because each condition represents a complex characteristic of the network, as explained in the previous section. It should thus be borne in mind that these numerical descriptors are by no means intended to quantify the (often) qualitative data on which the study is built. Each condition is a qualitative set of which a given observation might or might not be a member, which is expressed as '1' or '0'.

3.2. Test for necessary conditions

An analysis of the necessary conditions explores whether there is a specific condition that explains most of the variance observed in the outcome of interest. Framed differently, a test for necessary conditions seeks to understand whether the outcome of interest can only be produced if a specific condition or combination of conditions is present. If a condition is found to be necessary, this indicates that it is unlikely that the outcome of interest will be present without that condition. Nevertheless, this does not mean that, just because a condition is present, the outcome will also be present – in other words, a condition may be necessary but not sufficient for the outcome.

3.3. Test for sufficient conditions

To gain insight into the issues of equifinality (multiple paths leading to the same outcome) and conjunctural causation (multiple conditions interacting in one path), the data are logically analysed to reduce the empirically observed configurations related to the outcome of interest (Ragin & Rihoux, 2009, chapter 5, box 8.1; Schneider & Wagemann, 2012, chapter 11). A configuration is sufficient for the outcome observed in the data if it is the case that every time this configuration of conditions is present, the outcome is also present (Schneider & Wagemann, 2012). The solution of the QCA is the expression that represents the sufficient configurations of conditions.

The first step in this analysis is to create a truth table. The truth table depicts all the logically possible configurations of conditions, and is used to enable the logical minimization of the data. Following Ragin (2008), all empirical observations are considered in the analysis. From here on, standard analysis is carried out in FS/QCA (Version 3.0, Ragin & Davey, 2016), leading to the results presented in the next section.

4. Results

Of the initial 64 networks identified in the starting sample, 42 were discarded because of incomplete data or inactivity or because promoting urban climate action was not one of their goals (see Supplementary Material for details). For the remaining set of 22 networks, we were able to find valid and complete data for our csQCA (see Table 1). After mapping the engagement of cities in the 22 networks, we observed that only 45% of the climate city networks had a member base showing a high level of engagement ($n = 10$).

4.1. Test for necessary conditions

Table 1 does not indicate any clearly observable structure binding together this subset of climate city networks. This is confirmed by the analysis for necessity shown in Table 2.

Conditions should only be considered necessary if their consistency scores are very high; a cut-off point of 0.90 is advised (Ragin & Rihoux, 2009, p. 45). Thus, from Table 2, we learn that none of the conditions individually explains the outcome of interest, which is consistent with our assumption of conjunctural causation and equifinality.

4.2. Test for sufficient conditions

The following analysis of the sufficiency of the conditions allows us to understand whether and how the conditions interact (conjunctural causation), and whether there is one or more type of interacting conditions related to this specific performance outcome (equifinality). The truth table is represented in Table 3.

With the five conditions included in this study, the number of logically possible combinations is 32 (2ˆ5). All 22 empirical observations (the climate city networks) are included in this table (rows 1–12) – each observation is unpacked as a configuration of conditions. The frequency score indicates how many observations fit a specific configuration. The truth table also includes possible configurations without empirical observations, called logical remainders, in rows 13–32. The empirical coverage of our theoretical model of five conditions is 37.5% (12 observed configurations divided by 32 possible configurations).

Table 4 represents the complex solution resulting from this analysis. A complex solution builds solely on the empirical data obtained, and does not use counterfactuals for further simplification. We decided to stay with the complex solution because the existing literature does not give us enough confidence about the causal direction of each condition to push our analysis further (that is, to add intermediate or parsimonious solutions; see Schneider & Wagemann, 2012).

Table 4 adopts a straightforward notation and presentation of causal configurations ('paths') related to the outcome of interest (high level of member engagement in a climate city network). Upper case script indicates the condition is present and lower case script indicates the condition is absent in the causal configuration. There are five configurations related to climate city networks at least 35% of whose members are actively engaged. The solution coverage (1.00) is high (Ragin, 2008), indicating that the solution strongly relates to the outcome observed (see Schneider & Wagemann, 2012, section 5.3). The solution consistency (1.00) is also high, indicating that the solution is of high empirical importance in reaching the outcome. The paths can be considered as five causal recipes that are each sufficient to cause the outcome.

Table 4 indicates both conjunctural causation and equifinality. The formula also indicates that there are only a limited number of paths within our dataset that relate to the outcome (that is, we only observed five paths of the theoretically possible 32). The five paths we observed can be considered an evidence-based typology (limited to our dataset) of climate city networks with an active member base (Fiss, 2011). We stress that, while this typology sheds light on what climate city networks with an active member base look like, it does not give an insight into causality. That is, we cannot conclude at this point whether climate city networks with these configurations activate their members, or whether already active cities are attracted to networks with these configurations.

Table 1
Data from 22 climate city networks included in the study (developed by the authors). *Rockefeller Foundation disbanded RC100 in 2019. **NRG4SD was rebranded as Regions4 in 2019, their new website is https://www.regions4.org/.

Name	Website	GO	MT	IN	PS	MD	Member engagement
Red Chilena de Municipios ante el Cambio Climático (REDMUNICC)	redmunicc.cl	0	0	1	1	1	High
Red Argentina de Municipios contra el Cambio Climático (RAMCC)	ramcc.net	0	0	0	0	1	High
MobiliseYourCity Partnership	mobiliseyourcity.net	1	0	1	1	1	High
South African Local Government Association (SALGA)	salga.org.za	0	1	1	0	0	Low
The Climate Registry (TCR)	theclimateregistry.org	1	0	0	1	1	Low
The Regional Network of Local Authorities for the Management of Human Settlements (CityNet)	citynet-ap.org	1	1	0	1	1	Low
Cities Clean Air Partnership (CCAP)	cleanairasia.org/cities-clean-air-partnership	1	1	1	1	1	Low
World Association of the Major Metropolises (Metropolis)	metropolis.org	1	1	0	0	1	High
Federation of Canadian Municipalities (FCM)	fcm.ca	0	1	0	0	1	Low
R20 – Regions of Climate Action	regions20.org	1	1	1	1	1	Low
Under2Coalition	under2coalition.org	1	0	0	1	1	Low
Global Covenant of Mayors for Climate and Energy	globalcovenantofmayors.org	1	1	1	1	1	Low
Carbon Neutral Cities Alliance (CNCA)	carbonneutralcities.org	1	0	0	0	0	High
Climate Mayors (also known as Mayors National Climate Action Agenda, or MNCAA)	climatemayors.org	0	0	0	0	1	High
ICLEI – Local Governments for Sustainability	iclei.org	1	1	0	0	1	High
Climate Alliance of European Cities with Indigenous Rainforest Peoples	climatealliance.org	1	1	1	1	1	Low
100 Resilient Cities – Pioneered by The Rockefeller Foundation (100RC)*	100resilientcities.org	1	0	1	1	0	High
Union of the Baltic Cities (UBC)	ubc.net	1	1	0	0	1	High
Energy Cities/Energie-Cités	energy-cities.eu	1	0	0	1	1	Low
EUROCITIES	eurocities.eu	1	1	0	1	1	Low
Network of Regional Governments for Sustainable Development (NRG4SD) **	nrg4sd.org	1	1	0	1	1	Low
C40 Cities Climate Leadership Group	c40.org	1	1	0	0	0	High
Percentage of items coded 1		77%	59%	36%	59%	82%	45%

4.3. Further simplification

Rather than analysing the results of the QCA in isolation, we return to the qualitative nature of the process to consider the context of each of the identified network types. A close reading of the five types identified in Table 4 indicates that some conditions in the various paths recur in a specific pattern. The full solution can be represented in Formula (1):

$$\text{High member engagement} \rightarrow \begin{cases} \text{in*ps} \begin{cases} \text{GO} \begin{cases} \text{md} & \text{(path 1)} \\ + & \\ \text{MT} & \text{(path 2)} \end{cases} \\ + \\ \text{go*mt*MD} \quad \text{(path 3)} \end{cases} \\ + \\ \text{mt*IN*PS} \begin{cases} \text{GO} & \text{(path 4)} \\ + & \\ \text{MD} & \text{(path 5)} \end{cases} \end{cases} \qquad (1)$$

In Formula (1), the multiplication symbol (*) represents the logical AND, and the sum symbol (+) represents the logical OR; again, upper case script indicates the condition is present and lower case script indicates the condition is absent in the causal configuration. This formula indicates that climate city networks with at least 35% of their members actively engaged with their programmes and activities fit into two broad categories as well as the five specific types.

The first category is climate city networks initiated by cities (that is, networks that were originally established by cities and that do not have a permanent partnership with non-city organizations (in*ps)). Cities can form networks to support each other to influence transnational climate change politics (Bulkeley, 2010; Castán Broto, 2017). These networks – which represent horizontal climate governance – are usually used by cities as platforms to improve their position to implement urban climate action (Bulkeley, 2005; Kern & Mol, 2013). In these horizontal networks, cities have the independence to participate as they wish, and the decisions are directly implemented by the members (Kern & Bulkeley, 2009), which limits the resources available to the members (the networks often depend on the cities' resources to implement climate action, either through membership fees or through different city-to-city cooperation schemes). Within this context, cities with higher capacities have more resources to implement climate action and emerge as leaders or pioneers within the network, leading to the pattern of networks 'of pioneers for pioneers' identified in the literature (Kern & Bulkeley, 2009; Wurzel, Liefferink, & Torney, 2019). We identified three types of climate city networks within this category, of which the first two are international networks (GO) and the last is a national one. The types are:

- *Global elite networks* (path 1): These are international networks with strict membership criteria (md) that set high entry-barriers and target leading global cities. With strict membership criteria, these networks function like clubs of elite cities that impose higher than normal climate action standards on themselves. This type of network

Table 2
Analysis of necessary conditions.

Outcome variable	Member engagement	
Conditions tested	Consistency	Coverage
Geographical Orientation (GO)	0.700000	0.411765
Multi-tiered Structure (MT)	0.400000	0.307692
Initiator (IN)	0.300000	0.375000
Permanent Strategic Partnerships (PS)	0.300000	0.230769
Member Diversity (MD)	0.700000	0.388889

Table 3
Truth table.

	GO	MT	IN	PS	MD	Member engagement	Frequency
1	1	1	0	0	1	1	3
2	0	0	0	0	1	1	2
3	0	0	1	1	1	1	1
4	1	0	0	0	0	1	1
5	1	1	0	0	0	1	1
6	1	0	1	1	0	1	1
7	1	0	1	1	1	1	1
8	1	1	1	1	1	0	4
9	1	0	0	1	1	0	3
10	1	1	0	1	1	0	3
11	0	1	1	0	0	0	1
12	0	1	0	0	1	0	1

Rows 13–32: logical remainders.

is aimed at leading cities that are seeking to raise their visibility internationally and globally. While the members of such networks are usually already active on climate issues, it is unclear whether the networks help to spur climate action directly. However, as explored in the broader literature, since their members are aiming to be seen as global leaders, these networks raise awareness of urban climate action globally. A typical example is the C40 Cities Climate Leadership Group.

- *Regional/thematic leader networks* (path 2): These are international networks with thematic or geographic sub-networks (MT) that allow cities to be regional or thematic leaders. Sub-networks allow members to showcase their leadership within a specific geographical or thematic domain (e.g. climate leaders in Asia, or energy efficiency leaders). While global cities might take the most dominant roles in these networks, the fragmentation of activities creates opportunities for regional leaders or rising cities to take leadership positions. Although the resources are more limited than those of global elite networks, the sharing of best practice by these non-global cities might help to develop climate action that resonates better with smaller or less well-resourced cities globally. A typical example is ICLEI – Local Governments for Sustainability.
- *Supporting networks* (path 3): These are national networks with open membership criteria and without sub-networks (go*mt*MD). Cities in this type of network are similar to each other (at a minimum they are subject to the same national government). These networks do not have sub-networks, suggesting a common goal or theme for their members. Together with geographical closeness, this might provide more peer pressure among the members to stay actively engaged. The absence of sub-networks suggests a more straightforward agenda that binds together a set of relatively similar cities. While the level of resources might be limited, the small incentives for larger cities to participate mean that these networks can be useful to help smaller cities to tackle local problems or to engage in advocacy with their national governments. A typical example is the Red Argentina de Municipios contra el Cambio Climático (RAMCC).

The second broad category is climate city networks driven by non-city organizations. These are networks established by, and thus permanently linked with, a non-city organization (mt*IN*PS). In this category, we observe networks established by a non-city organization ('sponsor'), which sets the initial goal of the network and to a large extent provides or facilitates resources for it. Compared with the former category, this leads to a more hierarchical and centralized governance structure, in which member cities have limited opportunities to change the network. Sponsors pursue such networks to promote their climate agendas in the member cities. Members are, in turn, attracted by the potential of increasing their climate action capacity through the rewards offered for participation. Arguably, this arrangement offers an efficient way to scale up sponsor campaigns and provide cities with resources to take climate action locally. The logic of these networks is different from the initial conception of climate city networks as horizontal and decentralized (Bulkeley, 2005). However, cities are still autonomous and free to join or leave, and decisions taken within the network continue to be implemented by members, as in other climate city networks (Kern & Bulkeley, 2009). The reach of these networks and the broadness of their agenda are limited by the resources and interests of the sponsor organization. We identified two types within the category of climate city networks driven by non-city organizations:

- *International implementation networks* (path 4): These are international networks (GO) providing knowledge or financial support to their members. They are often established by a sponsor in order to diffuse, promote or scale up the sponsor's vision of urban climate action internationally. The network allows the sponsor to expand its geographical scope of action (to the international or global level), but this comes at a cost for the sponsor: the rewards for participation and engagement need to be of interest to (potential) members. Members can benefit from these rewards (in terms of resources, knowledge, and recognition), but, in return, are expected to follow the sponsor in how they take climate action locally. A typical example of this type is 100RC (see also Nielsen & Papin, 2020).
- *Goal-oriented networks* (path 5): These are networks with open membership criteria (MD) and a focused mission supported by a non-city organization. While similar to the previous type, the open membership in these networks suggests that the sponsor is more open to negotiating with the cities about the exact conditions they must meet to obtain rewards. For example, when the sponsor cannot

Table 4
Complex solution for high member engagement.

Solution	Formula	Coverage		Consistency	Climate city networks in this path
		Raw	Unique		
Path 1	in*ps*GO*md	0.20	0.10	1.00	CNCA, C40
Path 2	in*ps*GO*MT	0.40	0.30	1.00	Metropolis, ICLEI (Global), UBC, C40
Path 3	in*ps*go*mt*MD	0.20	0.20	1.00	RAMCC, Climate Mayors
Path 4	mt*IN*PS*GO	0.20	0.10	1.00	MobiliseYourCity, 100RC
Path 5	mt*IN*PS*MD	0.20	0.10	1.00	REDMUNICC, MobiliseYourCity
Solution coverage: 1.00					
Solution consistency: 1.00					

Note: Upper case indicates the condition is present; lower case indicates the condition is absent. Abbreviations: GS = geographical orientation; MT = multi-tiered structure; IN = initiator; PS = permanent strategic partnerships; MD = member diversity; * = logical AND.

provide sufficient direct rewards to the network members, it may need to negotiate over what the members are willing to do in terms of pursuing the sponsor's agenda and what the cost of this will be for the sponsor. This negotiation provides the members with more influence in these networks than in networks of the previous type. Nevertheless, it is still the sponsor who defines the broad goal of such networks and sets the network structure, allowing the sponsor to control the network. A typical example of this type is MobiliseYourCity.

5. Discussion and conclusions

City networks have rapidly emerged as an essential part of urban climate policy and governance. Our analysis contributes to the emerging climate city network literature that aims to understand the heterogeneity of these networks (Acuto & Rayner, 2016; Bansard et al., 2017; Lee & Jung, 2018). In this context, our csQCA analysis shows clear differences in how active membership takes shape in climate city networks, as defined by geographical orientation, a multi-tiered structure, type of initiator, permanent strategic partnerships, and member diversity. Within the set of 22 climate city networks analysed, we observed a subset of ten networks with high member engagement, and we clustered these into five different types ('paths') using csQCA. These types are global elite networks, regional/thematic leader networks, supporting networks, international implementation networks, and goal-oriented networks. As with any research project, however, some caveats apply. Our findings are limited to the set of 22 climate city networks in our study, and our application of QCA allows for 'moderatum generalizations' (Payne & Williams, 2005). That is, other studies using a different set of city networks are likely to find similar patterns and interactions between the outcome of interest and the conditions included. However, it is unlikely that they will find the identical detailed patterns and interactions that we have observed. The findings and conclusions that follow should be understood as a set of bounded generalizations and propositions about how city networks can (and do) achieve an active member base.

Our typology characterizes climate city networks by different configurations of conditions that foster an active member base. This indicates that each type of network identified uses a different strategy to engage with its members. Given this diversity of approaches, aims, and membership involvement among climate city networks, we can assume that it is also possible for cities to align with climate city networks that meet their own needs, whether they are looking for global recognition or for access to national partners as part of their overall climate strategy. Our typology, furthermore, gives insight into how climate city networks might wish to organize themselves to match one of the network types, should they aim for high(er) member participation. For instance, smaller cities with local climate aspirations and low capacity might benefit more from a climate city network like REDMUNICC, with its focus on supporting local climate actions (REDMUNICC, n.d.). By contrast, a city with global climate aspirations could benefit from engagement with the Carbon Neutral Cities Alliance (CNCA), which provides global prestige and support for cities aiming to cut their emissions by at least 80% by 2050 (CNCA, n.d.).

Taken together, these five types of networks can be aggregated into the two climate city network categories recognized in the literature (Gordon, 2018). The first category includes climate city networks established by cities. The second category, in contrast, is made up of climate city networks established by non-city organizations. These two categories highlight the influence on network membership of different governance structures and agendas (Acuto & Rayner, 2016; Bansard et al., 2017; Davidson et al., 2019; Lee & Jung, 2018). For example, climate city networks established by cities are likely to have a more horizontal and decentralized governance structure that matches the scale of the members implementing the network decisions (Kern & Bulkeley, 2009). Under this 'horizontal' structure, cities with more resources are expected to have more influence, thus creating a leader–follower pattern. In contrast, we found that climate city networks established by non-city organizations tend to be more centralized, as the establishing organization sets the goals and provides resources to the network, thus promoting its agenda to cities through the network. Our analysis shows that the type of entity that initiates a climate city network has a strong impact on the agenda and resources of the network. While in our (crisp-set) study this distinction was straightforward, the relationship between cities and non-city organizations within climate city networks is often nuanced and evolves over time, as cities reach out to non-city organizations for support or non-city organizations reach out to cities to promote their climate objectives by negotiating a common agenda. The relative power and influence can shift over time as the relationship between the cities and the non-city organizations evolves. Still, our observation confirms findings that we should not underestimate: (1) the relevance and influence of international actors such as the World Health Organisation in establishing city networks, and (2) the increased reaching out of climate city networks for funding to diverse organizations such as foundations, national governments and private companies (Acuto et al., 2017; Acuto & Ghojeh, 2019; Davidson et al., 2019).

While our methodology enables us to develop a typology of climate city networks with active membership, it does not enable us to discern whether these networks have attracted cities that were already active or whether cities became active after joining the network (but see, for example, Heikkinen et al., 2020). In addition, our choice of club theory also comes with some limitations: its two central areas of focus (club membership requirements and club rewards) proved helpful for finding patterns within city climate networks with active membership. The club theory perspective may be less helpful to understand why some city climate networks *do not have overall active membership*, whether and how active club members influence *non-active club members* within city climate networks, or even whether and how club benefits spill over from (active) city climate network members to (*active*) *non-club members* (see a similar argument in Green, 2017). These remain questions that are necessary to answer if we are to improve our understanding of the potential of climate city networks. Nonetheless, based on the observation that the networks are distributed among different types, we can conclude that there is diversity in the way in which climate city networks approach their members and seek to shape climate governance, which also indicates that networks cater for different cities with different needs. Likewise, our focus has been on the question of efficacy (the ability of climate city networks to promote climate action on the ground through their member cities). Future research may follow a similar approach to explore what typifies climate city networks that seek ends other than efficacy; for instance, value-driven ends such as inclusiveness, democracy, and heightened sensitivity to contextual and cultural conditions.

Our insight that climate city networks cater to a wide range of cities that wish to be active (or can be activated) in taking climate action is hopeful. It may be true that some climate city networks have become networks 'of pioneers for pioneers' (Kern & Bulkeley, 2009) that do not cater to the needs of (initially) less ambitious cities. However, we have shown that this does not prevent 'non-pioneer cities' from joining climate city networks that suit their specific needs. The growth of climate city networks, and specifically their functional differentiation, has brought us to a stage where the full set of climate city networks has become sufficiently heterogeneous to be attractive to more than just pioneers and leading cities. Future research may wish to explore whether the current options provided by climate city networks (the supply of engagement opportunities) meet the desires of cities (the demand for engagement opportunities). Such research may help to clarify whether climate city networks can and should enter other (niche) areas of engagement, or whether they have exhausted the possible types of engagement and now have to focus on other approaches to ensure active member engagement.

Another area for future research is to clarify how the types of climate city networks without an active member base differ from the networks observed here. The 12 climate city networks in our study without an active member base overall have similar conditions to the ten with an active member base, but these conditions are clustered in different configurations. Our research offers useful insights for climate city networks that wish to have a more active member base. These climate city networks can identify which conditions they are missing from one of the pathways we found and decide to go in that direction. Taken further, an implication of this is that climate city networks can be designed to attract specific types of cities, reaffirming their potential to link cities to the climate regime but raising questions as to whether different types of cities can cooperate with each other.

CRediT authorship contribution statement

Sayel Cortes Berrueta: Conceptualization, Methodology, Formal analysis, Investigation, Writing – review & editing. **Jeroen van der Heijden:** Conceptualization, Methodology, Writing – review & editing. **Ingrid Boas:** Conceptualization, Writing – review & editing. **Simon Bush:** Conceptualization, Writing – review & editing.

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.

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Appendix A. Supplementary data

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