Ambitious urban climate policy

A qualitative comparative analysis on variation in urban climate ambition in terms of target setting

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Abstract

Cities play a key role in daily human life. Over half of the world population lives in cities and this will only become more. Cities can be seen as the main polluters and the main victims of climate change, but also as leaders for climate action. These leaders are willing to start tackling climate change, especially trough making ambitious climate policy trough target setting. However, cities differ greatly in how ambitious their climate policy and climate targets are. While more physical and social aspects of cities and their relation to climate policy are covered in literature, governance related variables are less researched. This research focusses on what governance conditions explain variation in ambition in urban climate policy terms of target setting. This is done by conducting a fuzzy set Qualitative Comparative Analysis (fsQCA) using three conditions explaining whether a city is ambitious in its climate policy or not. The conditions assessed are whether is city is collaborating with international climate networks, whether the mayor of the city is left wing oriented, and whether the emission data of the city is up-to-date. To what extent a city is collaborating with international climate networks is analyzed by their membership to C40, ICLEI and GCoM. Expected is that all three conditions together lead to ambitious climate policy in terms of target setting. Using a carefully selected selection of 64 cases, the fsQCA is conducted. The main finding is that high collaboration in combination with up-to-date data or left-wing oriented mayor in combination with up-to-date data are sufficient for the outcome. Up-to-date data is a necessary condition for ambitious climate policy. The three conditions together, however, are not sufficient for the outcome.

Keywords: climate ambition, urban climate policy, fsQCA, urban governance, urban action.

Preface & acknowledgments

With great pleasure, I present my master thesis "Ambitious Urban Climate Policy". This research explores why some cities pursue ambitious climate policies in terms of target setting and other cities do not or less. Cities have a great potential for climate action, which is often fostered by setting ambitious climate targets, for instance, emission reduction targets. My thesis is written in order to fulfill the graduation requirements of my master Sustainable Development track Earth System Governance.

This research combines my quantitative background acquired in Psychology with the qualitative research methods I learned during my master. Learning qualitative comparative analysis was challenging, as it was new to me, leading me to numerous hours of reading books, following an online course, and eventually mastering the research method.

My internship at the Science Based Target Network alongside my thesis fostered an interest in target setting. Even though the internship and the thesis research did not align, the internship adds to my knowledge and insights in target setting and urban climate governance.

The target audience of this thesis is people interested in urban climate ambition, but also researchers and policy-makers interested in urban ambition, climate leadership, and laggards in climate action. In addition, this thesis can serve as an example for moderately large N-size QCA studies.

Studying abroad has always been a dream of mine, and it was a disappointment that I was unable to pursue an internship abroad due to the pandemic. I took matters into my own hands and decided to write my thesis and do my internship from Portugal. This taught me that when a situation is not ideal, you can turn it around and turn it into an opportunity.

To conclude, I would like to say a few words of gratitude. First, I would like to thank my thesis supervisor, Rakhyun Kim, for his support, feedback, and enjoyable online chats during the writing process. Second, I would like to thank my second supervisor, Walter Vermeulen, for his useful feedback and insights. Third, I would like to thank my internship supervisors, Laura Parry and Samantha McCraine, for their ideas and encouraging words. Fourth, I would like to thank fellow interns/students Hanneke van Haeff & Aashima Singh for their words of encouragement, reflections, and feedback. Finally, I would like to thank my friends who took the time to read my thesis and provide me with their thoughts and criticism.

I hope you enjoy reading my thesis.

Avalon van der Wal

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CDP	Carbon Disclosure Project
CsQCA	Crisp set QCA
FsQCA	Fuzzy set QCA
GCoM	Global Covenant of Mayors
GDP	Gross domestic product
GHG	Greenhouse gas
ICLEI	International Council for Local Environmental Initiatives (now Local Governments for Sustainability
IPCC	Intergovernmental Panel on Climate Change
NDC	Nationally determined contributions
OECD	Organisation for Economic Co operation and Development
SDG	Sustainable Development Goal
QCA	Qualitative comparative analysis

Introduction

Societal background

Today, over three billion people live in cities. Cities play a key role in daily human life, and it is projected that in 2030, more than five billion people will live in cities (United Nations, 2018). Urbanization is taking place at an extraordinary rate, and the number of cities in the world has doubled going from 5.000 cities in 1975 to 10.000 in 2015 (OECD/European Commission, 2020).

Although cities house half of the world's population, they only take up 2-4% of the earth's surface. Remarkably, cities are responsible for 60-80% of the global energy consumption and 75% of greenhouse gas emissions, making cities the key source of climate change (Solecki et al., 2018; Van der Heijden, 2019; United Nations Environment Programme, 2019).

Since urban lifestyles are perceived to be more resource-intensive than rural lifestyles, it is expected that the negative impacts of cities will grow exponentially rather than linearly (Van der Heijden, 2019). Risks associated with climate change are increasingly finding expression in cities, making cities next to the key polluter, the key victim (Sanchez et al., 2018, Van der Heijden, 2019).

Cities are at the center of economic and political activity (Hunt & Watkiss, 2010). Moreover, cities are especially vulnerable to climate change risks due to the high concentration of people, the high concentration of economic capital, economic activities, and the built environment (Huq et al., 2007; Marschütz et al., 2020). The changes in the environment and challenges related to climate change are deeply intertwined with urbanization processes and are happening at an unprecedented pace (EEA, 2012).

Scientific background

Climate policy is increasingly focusing on problems at the local level, giving more attention to urban climate change policy and urban climate action (Hunt & Watkiss, 2010). City authorities are constantly challenged to find ways to incorporate adaptation strategies into their work (Wamsler et al., 2013). Urban adaptation to climate change goes beyond being a local governance issue. Cities are complex systems, which interact with their surroundings, and cannot be seen disconnected from the wider context (EEA, 2012; Furtado et al., 2015). In the climate policy context, cities are local government actors, interacting with other cities, businesses and stakeholders, international networks, and national governments.

In 2012 when the Sustainable Development Goals (SDGs) were established and in 2015 when the Paris Agreement was signed, national governments committed to nationally determined contributions (NDCs) to demonstrate their commitment to taking climate action (United Nations, 2015). However, scholars argue that these national efforts are not enough to reach the goal of a maximum of 1.5 degrees Celsius above pre-industrial levels, determined by the IPCC (IPCC, 2018; UNEP, 2019). Furthermore, some scholars argue that cities can 'bridge the ambition gap' between what NDCs are doing, and what needs to be done to reach the goals of the Paris Agreement (Hsu et al., 2019).

Cities are showing their ambition of urban climate policy by establishing ambitious climate targets. These targets can range from biodiversity targets to renewable energy targets. Cities sometimes set even more ambitious targets than their national governments. Paris, for instance, set greater goals and more ambitious actions for city government operations than the national government of France (Heidrich et al. 2016).

The narrative that cities are taking a leadership role in climate change is gaining traction in the literature (Betsill & Bulkeley, 2006; Van der Heijden, 2019). Cities not only have a strong need for action, but they also have exciting potential for action. Cities can be sites of innovation and serve as an example or model for climate action (Hofstad et al. 2021; Zimmerman & Faris, 2011). Cities can take a leadership role, not only in the wider climate debate but also towards other cities, corporations within cities, and their national government (Van der Heijden, 2019).

The narrative of cities as climate leaders portrays cities as key actors in supplying solutions for challenges related to climate change (Marschütz et al., 2020; Van der Heijden, 2019). Cities are developing plans for reducing climate change risks and decreasing emissions as well as increasing the cities' climate resilience. Therefore, cities can be seen as a driver of change (Barber, 2013; Brescia & Marshall, 2018; C40 & Arup, 2016; Castán Broto, 2017).

Literature gap

Research has been done on physical and societal variables leading to more city climate policy ambition. For instance, a higher gross domestic product (GDP), population size, or public awareness can lead to more local climate policy ambition (Lee & Painter, 2015; Reckien et al., 2015; Solecki et al., 2018; Yeganeh et al., 2020). Literature also mentions positive and negative influences on the development of city climate policy or ambitious city policy in general. However, the governance variables leading to more climate policy ambition have not been researched thoroughly in literature (Van der Heijden, 2019). Moreover, since most research is focused on cities that have a pioneer or leader position, it is hard to get a grasp of which cities are lagging in climate target setting.

The new narrative of seeing cities as 'saviors' of climate action, leads to critique from scholars (Van der Heijden, 2019). The focus of existing literature is often on best practices, drivers of change, and leaders in climate policy and target setting. However, cities that serve as leaders, do not reflect all cities because they often have more resources, possibilities, and willingness to implement ambitious climate policies.

While there are some cities taking on a leadership role, Van der Heijden (2019) points out that this is no sign of a global tendency of cities taking climate action. In addition, a 'frontrunner paradox' can put too much emphasis on what frontrunners can achieve in comparison to what the average city is able and willing to achieve. The leader narrative can give a too optimistic impression of what cities are doing. Often, climate change is not regulated in cities, and when it is, it is treated as an afterthought rather than a priority (Heidrich et al., 2016).

Given the fact that cities play such a significant role in climate change and have such potential for climate action, it is remarkable that there is a poor understanding of why some cities are committed to taking climate action and why some cities are not. What drives cities to take climate action and setting climate policies is assessed in the literature. However, local governance variables are not thoroughly assessed. Case studies or small comparative studies are done in literature, but comparative studies with larger N-sizes are hardly done. Literature does not examine patterns that lead to ambitious climate policy. This, in combination with the need for more attention to the adaption of climate policy on the local level that Zimmerman & Faris (2011) highlight, triggers the need for more knowledge on what can explain the variation in ambition in urban climate policy.

Research aim & scientific and societal relevance

There is a poor understanding of what governance factors lead to ambitious city climate policy, together with the narrative of cities being 'saviors' in the climate debate, and the national and international attempts for climate action by setting climate targets. This thesis aims to research what governance conditions lead to ambitious cities climate policy in terms of target setting and why there is variation in ambition. By doing a qualitative comparative analysis (QCA), the conditions that lead to a more ambitious city climate policy will be researched. Therefore, the research question of this thesis is the following:

What governance conditions explain the variation in the ambition of city climate policy in terms of target setting?

Research into patterns in variation in climate ambition and policy is lacking. Using a qualitative comparative analysis (QCA) can unfold the interacting factors and conditions leading to more ambition. Literature, as well as climate action networks and city networks, mention 'ambitious climate policy,' while definitions of ambition are lacking in the literature. Moreover, no qualitative comparative analysis is done yet on what governance conditions explain the variation in ambitious climate policy in terms of target setting in cities. In addition, because the focus of research is often on best practices and leaders, no clear overview or conditions of laggards are present. QCA can offer insights into what characteristics are leading to cities lagging and patterns in characteristics of cities that are more ambitious in their climate policy.

This research can give insights into why some cities have more ambitious climate policies and others do not. This is highly relevant in fostering climate ambition and action. This research can give argumentation for city climate action, setting climate targets on city levels, and the role of urban actors in the wider context of global climate policy and action. National policymakers can place more emphasis on the role of cities. QCA can give more in-depth insights into what conditions are necessary or sufficient in driving ambitious climate policy in cities. If certain conditions show to be present in cities with ambitious climate policies, city policy makers or national policy makers can investigate how this condition can be implemented in their cities to foster ambition.

Theory

Cities as actors

Before heading into theory on ambitious climate policies of cities, climate targets, and variables leading to ambitious climate policies, the term ‘city’ needs to be defined. Depending on what academic background, lens, or aim one looks at cities, cities can have a range of definitions. For example, from a more spatial perspective, cities can be seen as a physical entity, or areas where there is a lot of consumption, employment, or workforce (Parr, 2007).

For this research, cities are defined as actors that interact with other actors, such as governments, other cities, and businesses. Cities are an administrative entity with defined boundaries. While the terminology and procedures differ, the head of the city is a mayor. Cities boundaries marked by the power of the mayor. Cities are governmental structures, planning and acting independently and in interaction with other governmental structures and actors. Therefore, what happens within a city is important, as well as interaction with other actors.

Ambitious city climate policy

The term ‘ambitious climate policy’ or ‘policy ambition’ is frequently mentioned in literature. Ambition indicates a willingness to act, a willingness to achieve an outcome, and implies determination in doing so. Although ‘ambition’ in the context of climate policy is frequently used, it is often not determined or defined in one statement.

To measure the ambition level of local governments, one can look at target setting (Aall et al., 2007). An example is setting targets regarding greenhouse gas emissions reduction, targets for renewable energy share, or phasing out of natural gas.

Tobin (2017) mentions targets for future emission reductions to be a defining factor in describing climate policy ambition. In his research on climate policy on the national level, countries with climate targets were defined to be ambitious when they ‘go beyond windfall reductions and are greater than those created by similar states’ (Tobin, p. 30, 2017). In addition, policies receiving adequate funding, that are legally binding, are specific in their emission reduction targets, and minimize the need for purchasing carbon credits are considered to be more ambitious (Tobin, 2017).

‘Ambition’ implies doing more than the rest, doing more than the previous plans, and being more thorough. A competition between the frontrunners of climate action has been going on since the early 2000s (Van der Heijden, 2018). For example, Sydney and New York have been setting reduction goals that are going far beyond the goals of their nation-states and other cities.

A valid question is why cities would even set climate goals and climate policy in the first place. Van der Heijden (2018) explains that the answer to that question relates to how cities are perceived, namely as the key contributors yet also the main victim of climate change. This view fosters the need, urgency, and potential of city climate action through target setting. Cities can even be seen as the low-hanging fruit of climate action. Cities are a site of green growth and economic modernization, which can be a driver for climate policy, as it can lead to economic prosperity. It can also be the case that cities have more ambitious climate action ambitions as they are mandated by their national governments to do so (Van der Heijden, 2018).

Concluding, ambitious city climate policy has to do with being a frontrunner, doing more than what organizations, national governments, or other actors, especially other cities, are doing (Tobin, 2017; Van der Heijden, 2018).

City target setting

Ambitious climate policy can be assessed by looking at the targets cities are setting. To continue on ambition being relative to 'what others are doing', climate targets can be compared and thereby determined which city is (more) ambitious than another city. The climate targets that cities set can be mandatory or voluntary. While cities are obliged to take on the mandatory targets, cities can decide voluntarily if they want to uptake voluntary climate targets. This voluntary decision to uptake voluntary targets relates to the willingness to act and can therefore be seen as more ambitious.

While target setting on higher governance levels is a more commonly known practice, cities have started setting targets as well. In 1996, Freiburg decided to cut its CO_2 emissions by 25% by 2010 (Haarstad, 2019). This opened the gates for cities all over the world to start their climate ambition by constructing targets for a range of climate-related subjects, such as energy, emissions, mobility, and biodiversity.

Voluntary commitments and target-setting can also be found in the business world. For example, corporations commit to climate targets, and certification schemes for products like soybeans and palm oil are playing a key role in international trade and for consumers. Goal setting can help to mobilize, stimulate, and direct climate action (Hofstad et al., 2021).

There can be many reasons behind why corporations and cities can set targets. For example, companies set targets because energy cost is rising, stakeholders put pressure on them, and they expect that governments will keep implementing policy measures to reduce GHG emissions (Gouldson & Sullivan, 2013). Pressure or expected measures from national politics can drive cities to already set targets for themselves. In addition, because of the time pressure of climate change, setting targets can offer a pathway to reach the goal of climate adaptation and climate resilience and can be part of risk management for cities.

Setting – ambitious – targets is not only celebrated in literature. There seems to be a gap between what cities claim to be doing and what they are really do - the ambition gap. Setting a target is one thing, but the concrete steps to get to this target also need to be present to reach this goal. Therefore, some scholars are skeptical about the effect of target setting in climate action (Haarstad, 2019). It can be tempting to point out that the climate targets are not leading to the transformative policies that must be put in place to lead to the wanted outcome.

Nevertheless, Haarstad (2019) also mentions that the skepticism on climate target setting is mostly based on the worst-case scenario. This worst-case scenario is that policymakers seem to be tackling climate change, while not so much is done. This can lead to a sense of false security and the idea that action is taken, which can shift focus from needed action. Haarstad (2019) turns this worst-case scenario around by asking 'what if we look at it from the other side?'. Target setting in the broadest sense – quantifying what you want to do – transforms an idea into something more tangible. Using the rhetoric of Foucault, Haarstad (2019, p. 67) argues that by using metrics, we can 'make the unknown knowable, and thereby, governable'. Because climate change has been put in metrics in the past couple of decades, governing and politicizing it has become possible. Target-setting can legitimize practices for sustainable development, and voluntary target setting by cities can thereby lead to transformations.

Variables explaining ambitious climate policy in terms of target setting

Governance related variables leading to ambitious climate policy in cities is less researched in literature than for example societal or physical related variables. While there are clear indicators that city size, perceived climate risks, GDP, and public awareness lead to more climate ambition, governance related variables are less assessed (Drews & Van den Bergh, 2016; Drummond et al., 2018; Lee et al., 2015; Solaki, 2013; Solecki et al., 2018)

In finding drivers for ambitious climate change policy, the characteristics of cities are evaluated rather than the attributes of the respective countries. Following the reasoning of Heikkinen et al., (2020), who found support for the argument that drivers on the city level are more important than drivers on the national level.

Literature shows that local priorities, the governance structure, administrative division of tasks, and the local political culture can be indicators of how ambitious the city climate policy is (Hawkins et al., 2015; Tobin, 2017). In addition, Lee & Painter (2015) argue that when cities have climate governance arrangements in place, they are more likely to develop comprehensive climate policies. Government arrangements could consist of relevant city departments, prominent level government officials, environmental NGOs, and research institutes. Factors such as institutional and policy capacities of the local governments and local political leadership are mentioned as indicators for cities to set climate targets.

Hoff & Strobel (2013) mention that on the actor-level, the most important actors in driving ambitious climate change policy are local climate change personnel. In line with that, Hawkins et al. (2015) found that when cities state environmental protection to be a priority, they are more likely to have resources specifically committed to staff for sustainability. Lacking administrative capacity forms a barrier to municipal action (Salon et al., 2014). When cities lack the human resources to implement policies, set targets, and control progress, they are less likely to do so (Betsill, 2001).

The following three variables are chosen for the conducted analysis: political orientation of the mayor, membership to international climate protection networks and data availability. These variables come forward in literature to be drivers of ambitious climate policy. Both membership to international climate networks and making data available show ambition in terms of willingness to act and doing more than others. In addition, the variables are not uncontested, making them interesting for analysis. The variables are mostly researched in literature on their own, and not in combination with other variables, and causal relationships are hard to pinpoint in literature. Some scholars found that political orientation of mayors is a driver for more ambitious climate policy, while others did not find argumentation for that. Membership to international climate networks are also assessed in literature, however, membership to international climate networks could also be a result of ambitious climate policy instead of a driver. Finally, up to date data seems to be an important part of setting ambitious targets, but how data availability interacts with the other variables is unclear.

Political orientation of mayor

The political orientation of the local mayor can be an indicator of climate policy ambition. On a national level, Tobin (2017) found that the presence of a left-wing government alone is sufficient in producing ambitious climate policy. For example, the left-wing political orientation of citizens is shown to increase public support of climate policies in Switzerland and Sweden (Hammar & Jagers, 2007; Tobler et al., 2012). Hoff & Strobel (2013) found that concerning their reduction targets, left-wing mayors were more active than right-wing mayors. As reasoning behind the more climate action and targets on the municipal level, Hoff & Strobel (2013) mention that local governments that are left-oriented commonly have a bottom-up approach. In contradiction, Hoff & Strobel (2013) did not find strong evidence that left-wing mayors were more ambitious than right-wing mayors as the left-wing mayors did not have significantly more climate change action plans in place than right-wing mayors.

However, Orderud & Kelman (2011) mention that left-wing mayors are better informed and believe in the stronger role of local governance in policy design and adaptation. Moreover, literature shows evidence that left-wing political orientation is strongly related to more public policy support (Drews & Van den Bergh, 2016).

Left-wing political orientation and policy support are related via explanatory factors (Drews & Van der Bergh, 2016). Personal values of citizens and worldviews can be seen as explanatory factors of more left-wing political orientation, and thereby increasing policy support. This link between political orientation and climate policy ambition concerns the government at stake, which does not necessarily have to be a national government, as well as the local citizens.

Membership to international climate protection networks

Another indicator of ambitious climate policies of cities frequently mentioned in literature is membership to international climate protection networks. Hawkins et al., (2015) showed in their research that local priorities, membership to international networks, and participation in regional governance are indicators of more ambitious climate policies. Hoff & Strobel (2013) add to Hawkins et al. (2015) by saying that membership to climate protection networks comes from a lack of guidance from national politics in climate policy. When there is no guidance on the state level, municipalities tend to seek direction from either local citizen initiatives, or international climate networks.

Membership to international climate networks influences urban climate policy by enabling internal mobilization, guidance in emission reduction goals, enabling information exchange, and support for projects (Bush et al., 2018).

City networks and international collaboration between cities is not a novel concept. For a century, cities have been cooperating in networks. However, for a decade, city networks asserted their power and have been influencing global agendas (de Losada et al., 2019). Three city networks receive the most attention in literature: Global Covenant of Mayors (GCom), ICLEI Local Governments for Sustainability (ICLEI), and C40 (Busch et al., 2018; Heikkinen et al., 2020; Krause, 2012; Reckien et al., 2018). These city networks are often seen as the most influential, the most far-reaching and the most ambitious.

In their research, Reckien et al., (2015) show that there is a strong positive correlation between membership to Climate Alliance or GCoM of European cities and climate mitigation and adaptation plans. Memberships to other international networks, such as C40 and ICLEI are shown to be significant drivers for climate action plans (Reckien et al., 2015). When cities are a member of ICLEI, the likelihood of more resources for advancing sustainability increases (Hawkins et al., 2015).

Gordon & Johnson (2018) underline the importance of international climate city networks as they mention it to be ‘the primary vehicle through which cities participate in the global response to climate change’. Becoming a member can be seen as the first step in taking climate action, even if becoming a member is not followed by action such as the adaptation of climate plans (Reckien et al., 2015).

The fact that the membership to international climate networks is shown in literature as a driver for ambitious climate policy can be related to the often voluntary basis of these networks. By voluntarily committing to international networks, cities can show and increase their ambition. Climate networks can increase knowledge building, connection to other cities, and information sharing (Gordon & Johnson, 2018). In their research, Heikkinen et al., (2020) found that city networks attract active cities, and cities that are members of two or more international city networks are more advanced in their adaptation process of climate policy than cities that are not**.** This can benefit the individual cities in becoming more ambitious in their climate policy. This can go both ways, as cities that are already interested in climate action are more likely to join.

Data availability

How well cities are performing and how much they can do also relates to how up-to-date their data is. Data in general, especially publicly available data, for example, publications of policies on their websites, or available mitigation plans, show transparency and can show the willingness of cities to act. In line with expectations, data availability also relates to whether the city has the human resources to keep its data up to date. For setting feasible targets, data is needed to construct these targets and to track the progress cities make. Lacking data is shown to be an indicator for cities that do not perform well (UN Habitat, n.d.). Data collection can show what cities are doing and drive data-based action.

Expectation

The variables mentioned, political orientation of mayors, membership to international climate networks, and data availability, lead to an expectation of how these variables play a role in ambitious climate policy. For QCA, hypothesis testing is not suitable as the research method is iterative and therefore requires going back and forth in theory and data. Going back and forth in research steps defeats the purpose of hypothesis testing, as setting up a hypothesis is done before the researcher assesses the data (Schneider & Wagemann, 2012). Instead of constructing hypotheses, the following theoretical expectation given.

If a city has a left-wing mayor, is highly collaborating with international city networks, and has up-to-date data, then the city has a more ambitious climate policy in terms of target setting. How these variables interact between themselves, and whether all variables need to be present for ambitious climate policy in place is unclear.

Methods

Qualitative comparative analysis

The research method used is a qualitative comparative analysis (QCA). This research method is developed in 1980 by Charles C. Ragin and is focused on assessing causation and finding patterns in data to assess cause and effect relations. In a QCA the causes are called conditions, and the effect is called the outcome.

One of the main added values of QCA is that it can investigate complex causality. Not only can QCA show how conditions work together causing an outcome (conjunctural causality), but it can also show how one condition, or a combination of conditions can lead to the same outcome (equifinality). In addition, the context specificity of different conditions can be assessed in QCA. Lastly, there is asymmetry in the complex causality that QCA assesses, where the occurrence of an outcome does not immediately lead to the explanation of the non-occurrence.

Although the name 'qualitative comparative analysis' implies otherwise, QCA can be seen as a combination of qualitative and quantitative research methods. Pappas & Woodside (2021) see QCA, especially fuzzy-set QCA, for which conditions set scores can be on a range from 0 to 1, as linking qualitative and quantitative methods. In addition, while calibration is commonly used in natural sciences, it is not so much used in social science. Pappas & Woodside (2021) state that calibration can be used to satisfy the needs of qualitative as well as quantitative researchers. Where qualitative researchers can interpret relevant and irrelevant variation, the method allows quantitative researchers to position cases relative to each other.

The conditions that are required to create the result are known as *necessary conditions*. The necessary condition is present in all cases that display the outcome, the outcome cannot happen without the necessary condition. The presence of necessary conditions does not always lead to the outcome, but for getting the outcome the necessary condition has to be present (Schneider & Wagemann, 2012). When *sufficient conditions* are present, the outcome is also present. However, due to asymmetry, when sufficient conditions are absent, that does not automatically mean that the outcome is not present.

QCA is a research *approach* as well as an analytical *technique*, and in order to use QCA to its full potential, these two complementary ways need to be acknowledged. Wagemann & Schneider (2010) stress that QCA as a research *approach* mostly refers to the iterative process of data collection. In addition, QCA does not rely on a set of assumptions, which most quantitative techniques do rely on. This is where the qualitative roots of QCA come forward, as in traditional qualitative comparative research it is more common to in-/exclude cases, to recode variables, or even re-conceptualize entire variables. However, this would be labeled problematic in quantitative research. QCA as an analytical *technique* refers to the analytical way to look at the data when it is all selected and calibrated. QCA as an analytical technique uses specific software, intending to find empirical patterns in the data.

How does a QCA work?

QCA has a set-theoretic approach, sets being a collection of objects. In the calibration phase, the cases in sets are given scores to indicate to what extent or if they are part of a set. The goal of this research is more inductive, as it is not focused on testing a theory, but exploring city-data bottom-up. Important to note is that QCA studies are often both inductive and deductive, as finding the variables mentioned in the theory (membership to international climate network, the political orientation of mayor, up to date emission data) are derived from existing theories. However, in trying to explain variations in urban climate policy ambition, the research is more inductive, therefore, no hypotheses are constructed.

QCA is an iterative process, consisting of seven steps, shown in figure 1, which are explained using Rihoux & Ragin's (2009) theory.

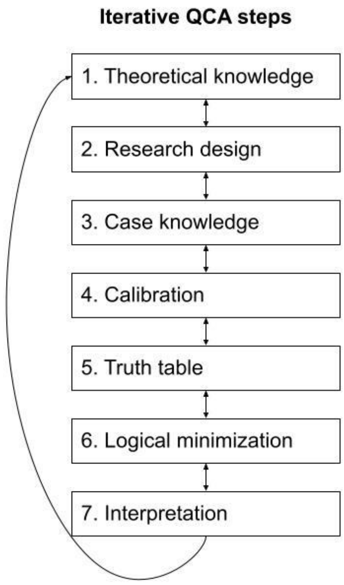

Figure 1. Steps of a QCA study

Step one in QCA is gaining theoretical knowledge. Theoretical knowledge entails the theories and concepts related to the topic of the QCA. In this research, the first step of the QCA is described in the theory section. This theory serves as the foundation for the possible patterns and variables leading to the outcome. Using the theoretical knowledge, step two, the research design can take place. The research design relates to the scope of the research, and how the research will be constructed. The research design for this thesis is discussed in the method section. The third step in QCA is gaining case knowledge. This is collecting data and gaining insights into the cases that are analyzed in the QCA. The fourth step is calibration. In the calibration phase, scores are assigned to each case to indicate whether or not the cases are a member of the sets. For this, rules of when a case is a member of a set or not need to be constructed. Both quantitative and qualitative data can be used. While quantitative data can be directly transformed to membership scores, qualitative data need to be assigned scores based on findings and data. This requires a two-step process, where first the sources of data are analyzed, and then transformed to membership scores. The membership scores are put in a truth table, which shows which sets of cases have the same combination of conditions and which cases have the same outcome. The sixth step is logical minimization. In this step, the truth table rows are systematically compared. The seventh and last step of QCA is the interpretation, in this last step, the outcome of the logical minimization is interpreted and put into perspective of existing literature. Due to the iterative approach, the researcher can go back and forth in research steps, and even after interpretation go back to the theoretical knowledge if needed.

The traditional QCA is called crisp set QCA (csQCA) and only has dichotomous conditions. This means that a case either falls into a set or not. This leads to binary variables, 0 or 1. For this research, another type of QCA, namely a fuzzy set QCA (fsQCA) is used. This type of QCA allows cases to fall into a range between 0 and 1. A case can be partly a member of the condition, barely part of a condition, or at the 'cross-over point' (0.5). This makes sense for this research, as not all variables can be translated into dichotomous conditions nor is that desirable. FsQCA allows for more nuance between cases. While csQCA and fsQCA differ in analysis, the foundation of the method is the same, therefore, when QCA is mentioned in this research, it entails both csQCA and fsQCA.

Criticism on QCA

As with every research method, especially with newer established research methods like QCA, this method is prone to criticism. The key criticisms are presented to offer a fair understanding of how QCA works. First, one drawback of QCA is that because it is not designed as a statistical technique, there is no way to determine the likelihood that the patterns discovered are the product of chance (Braumoeller, 2017). Second, Braumoeller (2017) mentions the existence of false positives or type I errors. Last, Paine (2016) argues that it is hard to demonstrate the advantages of set-theoretic comparative methods (like QCA) over traditional statistical modeling.

Proponents of QCA debunk the arguments of the opponents by stating that QCA cannot be compared to statistical analyses in the way critics do. QCA uses a different logic of interference, therefore not the same hypotheses as in statistical methods can be drawn (Thiem et al, 2015). Following the line of reasoning of Tobin (2017), the results of the QCA in this study should not be seen as definitive explanations of variation of urban climate policy ambition. Using QCA enables this study to test variables in combination, and thereby offers a robust means for case study selection. This type of research is yet to be used on urban climate ambition studies, and thereby offers an interesting perspective on the topic. While not stating that QCA is favorable over statistical analysis, but underlining the different angles and insights QCA can give, and thereby complementing other (statistical) methods.

Conditions, outcomes & cases

The three main elements in QCA are conditions, outcomes, and cases. A condition differs from a variable, therefore the variables determined in the theory section were operationalized and turned into conditions (Pappas & Woodside, 2021). The variables analyzed in this fsQCA are: membership to international networks, political orientation of mayor, and data availability.

The condition of membership to international climate networks was determined as high collaboration with climate networks. High collaboration with climate networks was shown in literature to be an indicator of more ambition, especially membership to two or more international networks. To measure high collaboration with climate networks, membership to the three most prominent international networks were used as indictors: whether the city is a member of C40, whether the city is a member of ICLEI, and whether the city is a member of GCoM. These international city networks are very commonly known, and especially C40 is exclusive yet very influential. The condition for local political orientation was determined as left-wing local government. Literature gave indications that left-wing mayors are more ambitious in their climate policy. 'Mayor' was determined in a broad sense, so lord mayors and city managers also fall under 'mayor' as they serve the same function in different cities but are not called the same. The condition for data availability was determined as up-to-date emission data. Up-to-date data came forward in literature to be important of ambitious target setting. Because data availability is challenging to gather, up-to-date emission data was used for this condition.

In QCA, the effect of cause and effect relations is called the outcome. In this research, the outcome was ambitious urban climate policy in terms of target setting. Cities with the outcome are considered ambitious, cities without the outcome do not fall into the set ambitious cities. Therefore, it this research, cities without the outcome are considered not ambitious. For the outcome to be met, cities needed to be part of the Cities A list 2020 by the Carbon Disclosure Project (CDP) (CDP, 2020). The cities on this list have set the most ambitious targets and have made a lot of progress since the signing of the Paris Agreement. The cities on this A list set ambitious yet realistic goals and have taken action to achieve these goals. These cities do better relative to other cities and uptake a leadership role to serve as an example for other cities and to foster ambition.

Case selection

The cases were carefully selected. Rihoux & Ragin (2009) mention points to consider for the selection of the cases. First, it is important to select cases that vary but at the same time are similar enough to compare. Second, cases with and cases without the outcome need to be part of the analysis. Third, data availability needs to be considered. QCA does not allow for missing data, so either the condition or the case needs to be deleted when data is lacking.

For the outcome to be met, cities needed to be part of the CDP Cities A list 2020 (CDP, 2020). This list consists of 88 cities. All cities were divided into size categories according to the classification of the OECD (OECD, 2020). This classification divides cities into large metropolitan areas (population of 1.500.000 or higher), metropolitan areas (population between 500.000 - 1.500.000), medium-size urban areas (population between 200.000 – 500.000), and small urban areas (population of 50.000 - 200.000). To ensure comparability in size, and to control for variation due to size differences, all small urban areas and large metropolitan areas were excluded from the analysis. By doing so, only cities with a population between 200.000 and 1.500.000 inhabitants were used for the analysis. In addition, only cities located in OECD countries were included in the analysis. Not only can it be argued that cities in OECD countries are more similar, but there is also more data available in these cities. Using these criteria for case selection, 32 cities from the CDP A list were selected for analysis, as they are located in OECD countries and have a population size between 200.000 and 1.500.000 inhabitants.

For the cities without the outcome, 32 cities comparable in size and location to the 32 cities with the outcome were selected. Preferably, cities from the same countries as the cities from the CDP A list were selected. In practice, not all countries have multiple cities with more than 200.000 and less than 1.500.000 inhabitants not already part of the CDP A list. For these countries other countries in that region were chosen to select cities from. All these countries are OECD countries, and the cities selected are comparable in size and GDP to the cities from the CDP A list. This lead to 32 cities located in OECD countries with a population size between 200.000 and 1.500.000 inhabitants without the outcome.

In total, 64 cities comparable in size were selected. This is a ‘moderately large N’ research design, (between 50 and 100 cases) (Vis, 2012).

Data

The databases online mostly consist of secondary data collected on the cities, but also data that the cities themselves disclosed. For the first condition, high collaboration, online available membership data was used. For the first indicator of this condition, membership to C40, the list of C40 cities was used available on their website (www.C40.org/cities). The list of ICLEI members was also available on their website (https://iclei.org/en/members-search.html). Lastly, GCoM data was also available online on their website (https://www.globalcovenantofmayors.org/our-cities/). For this condition, a four-value fuzzy set as mentioned by Rihoux & Ragin (2009) was used. Where a score of 1 is fully in, 0.66 is more in than out, 0.33 is more out than in and 0 is fully out of the set.

Whether a local city government is left or right-wing oriented was defined by looking at the orientation of the mayors of each of the cases. Who is the mayor of each city is stated on local government websites and required data collection by using local government sites and public data to determine whether a city mayor is left or right-wing oriented, or rather neutral. For the political orientation of the mayor, a three-value fuzzy set was used, where 1 is fully in, 0.33 is more out than in, and 0 is fully out of the set. Constructing fuzzy sets with 0.5 is unfavorable, because in the truth table it is unclear what this score means, as it is at the crossover point and therefore leads to ambiguity. To solve this, nonpartisan, independent, or neutral mayors received a 0.33 membership score, as they are not explicitly left-wing. For this condition, was researched to what extent left-wing oriented mayors lead to ambitious climate policy. Therefore, mayors who do not come out as left-wing oriented mayors by being members of a neutral party or nonpartisan were considered more out of the set than in.

For data availability and up-to-date data, CDP maintains a database where cities willingly disclose their data. Specifically, emission data gives an insight into what cities are doing, and disclosing this can show ambition for further climate policies. This data is available through their website (https://data.cdp.net/Emissions/). For this condition, a dichotomous set was used, where 1 is fully in, and 0 is fully out of the set.

Table 1 depicts the conditions, indicators, and classifications. A QCA is in the middle of qualitative and quantitative data, and both can be used to research the outcome and the relationships between the conditions and the outcome.

Table 1. Scoring of conditions for QCA

Condition	Classification		Score
High collaboration	Membership to C40	Yes/no	3 yes: 1 2 yes: 0.66 1 yes: 0.33 0 yes: 0
	Membership to ICLEI	Yes/no	
	Membership to GCOM	Yes/no	
Left wing local government	Left wing-oriented mayor		1
	Neutral mayor		0.33
	Right wing-oriented mayor		0
Up-to-date emission data	Yes		1
	No		0

For analyzing QCA data, calibration, constructing a truth table, and logical minimization, fsQCA software fsQCA 3.0 WINDOWS which is available online was used (https://compasss.org/software/). Using this software, the causal relationships, as well as the contextual conditions were assessed. The software produces tables and thereby insights what solution pathways and conditions are necessary or sufficient for the outcome. A guideline written by the inventor of QCA as a research method supported in conducting the analysis (Ragin, 2017).

Ethical issues, validity & reliability

Ethical issues must not be a problem in this research, all data was collected online and published by the local authorities, are disclosed by the cities themselves, or are published on the websites of the international climate networks.

Concerning validity, this research and QCA as a research method included a few measures to ensure validity. Since QCA is in an iterative process, it is important to keep going back and check that the conditions, indicators, and variables are still valid. This process ensured that the best fitting conditions and calibration are used to come to the results. Important to note is that this research was demarcated to governance variables of which the data is available for all cases. While there are more indicators possibly explaining variations in city climate policy ambition, including too many indicators in the analysis can lead to a too complex QCA solution which is not able to give useful insights into the research question. Solutions that are too hard to interpret are more susceptible to individual interpretation. So, for internal validity, it was beneficial that the number of conditions were not too high. Moreover, the conditions assessed use thresholds and not only dichotomous scores were used for the calibration in QCA, which gives a more nuanced view of the data. In terms of external validity, especially the generalizability of the results, the larger N-size of this research makes the results more generalizable. The case selection contained cities from multiple regions in the world. However, as also stated by Rihoux & Ragin (2009) only modest generalizations can be produced by QCAs. Crucial to keep in mind is that generalizations can only be made about cases (cities) that are in the homogeneity space of the initial data set. So, statements about unobserved cases can only be made about cases that meet the case selection criteria.

To ensure the reliability of the research method, a few measures were taken. All the data was, when available, data from the same year for all the cases. When data from the same year was not available, data from the most recent year available was used. This data was available online or disclosed by cities themselves.

If the research was conducted in the same way using the same thresholds, the same truth table should come out of it. To ensure replicability, especially the calibration phase needs to be transparent, therefore this research included the calibration rules and scoring. Because the analysis is done using QCA software, the same steps can be taken to come to the same outcome. However, a large part of QCA is the interpretation of, for example, the conditions and the scores. Previous research on the sensitivity of QCAs has shown that the results are sensitive to the researchers' interpretation (Skaaning, 2011). Another note to make is that because the world and especially cities are changing at a fast pace, the data used in this research can become outdated in a short amount of time.

The QCA and the chosen data shows what conditions will be sufficient and what combinations of conditions can be sufficient in explaining variation in city climate policy ambition in terms of target setting. The fsQCA allows for greater differences and nuances in the degree to which the city is part of the set or not. Therefore, this research method answers the research question, as an overview of what explains the variations in climate policy ambitions of cities can be taken from the method.

Results

Data matrix

The cases that are selected using the case selection criteria are summarized below in table 2. All cases are calibrated using the rubrics described in table 1 in the method section. The full dataset can be found in Appendix 1 and 2. Cities with outcome 1 are ambitious in their climate policy in terms of target setting, cities with outcome 0 are less ambitious in their climate policy in terms of target setting. In other words, ambitious cities are cities with the outcome (outcome =1), non-ambitious cities are cities without the outcome (outcome =0).

In the data matrix a few things already stand out. First, none of the cities without the outcome score a 1 on high collaboration, meaning that none of the cities without the outcome are part of all three international climate networks. On the other hand, only three cities with the outcome score 1 on high collaboration. Second, all cases that have the outcome also have their data up to date.

In the data matrix, contradictory rows can be identified. Contradictory rows are cases with membership to the same conditions, but with a different outcome. For example, New Orleans (condition 1 = 0,66, condition 2 = 1, condition 3 = 1, outcome = 0), this city has the same membership scores as for example Bristol (condition 1 = 0,66, condition 2 = 1, condition 3 = 1, outcome = 1), however, Bristol is part of the outcome. Contradictory rows need to be avoided in QCA studies, either before logical minimization or during logical minimization (Schneider & Wagemann, 2012). For this research, all contradictory rows are used in the logical minimization process. Reasoning along the lines of Schneider & Wagemann (2012), the contradictory rows make the presence of the outcome possible. A downside of leaving the contradictory rows in, however, is that in the solution term also includes cases that are not a member of the outcome.

Table 2. Data matrix

Cases	Cond_1_High_Collab	Cond_2_Mayor_Pol	Cond_3_Uptodata	Outcome
Canberra	0,33	1	1	1
Adelaide	0,66	0,33	1	1
Municipalidad de Peñalolén	0,33	1	1	1
Municipalidad de San José	0,33	1	1	1
Ayuntamiento de Hermosillo	0	1	1	1
Copenhagen	1	1	1	1
Stockholm	1	0	1	1
Ayuntamiento de Murcia	0,33	1	1	1
Ayuntamiento de Vitoria-Gasteiz	0,66	0	1	1
BCP Council/Bournemouth	0,33	0	1	1
Bristol	0,66	1	1	1
Espoo	0,66	0	1	1
Helsinki	0,66	0	1	1
Porto	0,33	0,33	1	1
Florence	0,66	1	1	1
Torino	0,33	0,33	1	1
Malmö Stad	0,66	1	1	1
Newcastle	0,33	1	1	1

Zürich	0,66	1	1	1
Boston	0,66	1	1	1
Miami	1	0	1	1
San Francisco	0,66	1	1	1
Cleveland	0,33	1	1	1
Columbus	0,66	1	1	1
Denver	0,66	1	1	1
Baltimore	0,66	1	1	1
Louisville, KY	0,33	1	1	1
San Antonio	0,66	0,33	1	1
San José	0,66	1	1	1
Washington D.C.	0,33	1	1	1
Windsor	0,33	0,33	1	1
Halifax Regional Municipality	0,33	0,33	1	1
Wellington	0,33	0,33	1	0
Hobart	0,66	0,33	1	0
Vina del Mar	0	1	0	0
Tepic	0	1	0	0
Saltillo	0,33	0,33	0	0
Aarhus	0,33	1	0	0
Gothenburg	0,66	0	0	0
Córdoba	0,33	0	0	0
Pamplona	0,33	0	0	0
Glasgow	0,66	1	0	0
Liverpool	0,33	1	0	0
Stuttgart	0,33	1	0	0
Nantes	0,66	1	0	0
Montpellier	0,66	1	0	0
Palermo	0,33	1	0	0
Bologna	0,66	1	1	0
Debrecen	0,33	0	0	0
Plymouth	0	0	1	0
Geneve	0,33	1	0	0
El Paso (TX)	0	1	0	0
Virginia Beach (VA)	0	0	0	0
Indianapolis (IN)	0	1	1	0
New Orleans (LA)	0,66	1	1	0
Charlotte (NC)	0,33	1	1	0
Fort Worth (TX)	0	0	0	0
Jacksonville (FL)	0,33	0	0	0
Omaha (NE)	0	0	1	0
Tampa (FL)	0,33	1	0	0
Mesa (AZ)	0	0	0	0

Nashville (TN)	0,66	1	1	0
Oshawa	0	0,33	0	0
Victoria	0,66	0,33	1	0

Necessary conditions

In table 3, the necessary conditions are analyzed. This shows the coverage and consistency of the conditions. Consistency shows the degree to which the condition is a superset of the outcome. Coverage shows the empirical relevance of a consistent superset.

The condition with the highest consistency score is condition three, up-to-date data (1.00). The consistency score indicates that condition 3 is necessary for the outcome. When the outcome is present, condition 3 is present as well. However, the opposite is not true, when condition 3 is present, the outcome is not always present, therefore this table does not show whether condition 3 is also sufficient for the outcome. Sufficiency is assessed is in the truth table and logical minimization. The fact that up-to-date emission data shows to be a necessary condition is interesting, as it might lead to the conclusion that up-to-date data simply describes the cases with the outcome. However, up-to-date data is needed when constructing climate targets, and cities further in the process of setting climate targets need to have their data up to date. Necessary conditions, and in this case the presence of up-to-date data does not give insights into the causal direction. By just looking at necessary conditions, it is unclear if cities are already setting ambitious climate targets and therefore getting their data up to date, or the other way around.

The other individual conditions have lower consistency and coverage than the up-to-date condition. From the necessary condition analysis, no claims can be made whether the outcome will occur or not, just that up-to-date emission data is a necessary condition for the outcome to occur.

Table 3. Analysis of Necessary Conditions

	Consistency	**Coverage**
Cond_1_High_Collab	0.537187	0.626915
Cond_2_Mayor_Pol	0.686875	0.540980
Cond_3_Uptodata	1.000000	0.761905

Subset/Superset Analysis

The subset/superset analysis in table 4 shows the scores of consistency and coverage for the conditions and the configurations of the conditions. The combined score is given as well. Consistency of a subset relation is the extent to which the set is contained within another set. Raw coverage shows to what extent the outcome is covered by a solution. This subset/superset analysis allows examining the sufficiency of a (hypnotized) causal recipe. Conditions with a consistency of 0.75 or higher can be seen as sufficient for the outcome.

Table 4 shows that condition 1 AND condition 2 AND condition 3 together is a subset of the outcome and therefore sufficient for the outcome. The coverage, however, is quite low, having implications for the empirical relevance of this finding. Condition 1 AND condition 3 are also sufficient for the outcome. Condition 2 AND condition 3 are also sufficient for the outcome. The raw coverage of condition 2 AND condition 3 is quite high, indicating that more cases are included in that solution term and have the outcome.

Negation of the outcome, or the non-occurrence of the outcome (~Outcome) in table 5 shows that none of the configurations and the condition are a subset or superset of the non-occurrence of the outcome.

Table 4. Subset/Superset analysis

Terms	Consistency	Coverage	Combined
Cond_1_High_Collab*Cond_2_Mayor_Pol* Cond_3_Uptodata	0.787371	0.381875	0.538725
Cond_1_High_Collab*Cond_2_Mayor_Pol	0.616860	0.381875	0.269363
Cond_1_High_Collab*Cond_3_Uptodata	0.812766	0.537187	0.667732
Cond_2_Mayor_Pol*Cond_3_Uptodata	0.785842	0.686875	0.722513
Cond_1_High_Collab	0.626915	0.537187	0.335871
Cond_2_Mayor_Pol	0.540980	0.686875	0.219274
Cond_3_Uptodata	0.761905	1.000000	0.830662

Note the consistency and coverage in the subset/superset analysis is identical to the coverage and consistency in the analysis of necessary conditions in table 3. The formula is mathematically identical, which relates to fact that necessary and sufficient conditions are to some extent opposite to each other. While the formula is identical, the interpretation differ (Schneider & Wagemann, 2012).

Table 5. Negated subset/superset analysis

Terms	Consistency	Coverage	Combined
Cond_1_High_Collab*Cond_2_Mayor_Pol* Cond_3_Uptodata	0.212629	0.103125	0.032113
Cond_1_High_Collab*Cond_2_Mayor_Pol	0.383140	0.237187	0.068875
Cond_1_High_Collab*Cond_3_Uptodata	0.187234	0.123750	0.035178
Cond_2_Mayor_Pol*Cond_3_Uptodata	0.214158	0.187187	0.043265
Cond_1_High_Collab	0.373085	0.319687	0.079961
Cond_2_Mayor_Pol	0.459020	0.582812	0.132228
Cond_3_Uptodata	0.238095	0.312500	0.055902

Truth table

Table 6 shows the truth table of the analysis. Including the configuration of the conditions, the number of cases included in the configuration, the cases, the raw consistency, the PRI consistency, and the SYM consistency. The truth table has as many rows as there are logically possible combinations in the causal conditions. There are 2^k rows, where k stands for the number of causal conditions, in this research that is 3, so there are logically $2^3 = 8$ configurations possible. The rows in the truth table represent a summary of the cases with a certain combination of input values. The frequency threshold is set to 1 as this is common practice in most QCA studies (Schneider & Wagemann, 2012).

Raw consistency (raw consist. in table 6) is the extent to which the membership is a subset of membership in the outcome. PRI consistency stands for an alternative measure of consistency derived from quasi-proportional subtraction in error calculation. SYM consistency is another measure for consistency based on PRI consistency.

The truth table shows how often the logically possible configuration occurs, a truth table is not an end in itself, it leads to logical minimization. The minimum consistency threshold usually used for QCA is 0.75 to 0.80. The consistency threshold shows whether a condition or combination of conditions is sufficient for the outcome. For this research, the threshold is set at 0.75, as there a quite a number of cases in this data set (Schneider & Wagemann, 2012).

The sets of cases sharing a combination of conditions also sharing the outcome are the subset of the outcome and sufficient for the outcome. In the truth table (table 6), the outcome value for these rows is 1.

In table 6, cases included in configurations shown in rows 1, 2, and 3 are sufficient for the outcome as the raw consistency is larger than 0,75.

Table 6. Truth table

Cond_1_ High_Collab	**Cond_2_ Mayor_Pol**	**Cond_3_ Uptodata**	**Number**	**Outcome**	**Cases**	**raw consist.**	**PRI consist.**	**SYM consist**
1	0	1	9	1	Adelaide, Stockholm, Ayuntamiento de Vitoria Gasteiz, Espoo, Helsinki, Miami, San Antonio, Hobart, Victoria	0.80814	0.80814	0.80814
1	1	1	14	1	Copenhagen, Bristol, Florence, Malmö Stad, Zürich, Boston, San Francisco, Columbus, Denver, Baltimore, San José, Bologna, New Orleans, Nashville (TN)	0.787371	0.787371	0.787371
0	1	1	11	1	Canberra, Municipalidad de Peñalolén, Municipalidad de San José, Ayuntamiento de Hermosillo, Ayuntamiento de Murcia, Newcastle, Cleveland, Louisville (KY), Washington D.C.,	0.761349	0.761349	0.761349

					Indianapolis (IN), Charlotte (NC)			
0	0	1	8	0	BCP Council/ Bournemouth, Torino, Windsor, Halifax Regional Municipality, Wellington, Plymouth, Omaha (NE)	0.60119	0.60119	0.60119
0	0	0	9	0	Saltillo, Córdoba, Pamplona, Debrecen, Virginia Beach, Fort Worth (TX), Jacksonville, Mesa (AZ), Oshawa	0	0	0
0	1	0	9	0	Vina del Mar, Tepic, Aarhus, Liverpool, Stuttgart, Palermo, Geneve, El Paso (TX), Tampa (FL)	0	0	0
1	1	0	3	0	Glasgow, Nantes, Montpellier	0	0	0
1	0	0	1	0	Gothenburg	0	0	0

Logical minimization

Logical minimization in table 7 systematically compares the truth table rows of table 6 with sufficient combinations of conditions. The solution pathways of the logical minimization are given in table 7. The full truth table analysis can be found in appendix 3.

Raw coverage shows the coverage of that solution term, showing how much of the outcome is explained by the specific solutions. The unique coverage shows the extent to which the outcome is uniquely covered by the specific solution term. Consistency shows to what extent the solution term is a subset of the outcome.

Table 7. Complex, parsimonious, and intermediate solution

Solution		
Frequency cutoff		1
Consistency cutoff		0.761349
	Cond_1_High_Collab*Cond_3_Uptodata	Cond_2_Mayor_Pol*Cond_3_Uptodata
Raw coverage	0.537187	0.686875
Unique coverage	0.155312	0.305

Consistency	0.812766	0.785842
Cases included	Copenhagen (1,1), Stockholm (1,1), Miami (1,1), Adelaide (0.66,1), Ayuntamiento de Vitoria-Gasteiz (0.66,1), Bristol (0.66,1), Espoo (0.66,1), Helsinki (0.66,1), Florence (0.66,1), Malmö Stad (0.66,1), Zürich (0.66,1), Boston (0.66,1), San Francisco (0.66,1), Columbus (0.66,1), Denver (0.66,1), Baltimore (0.66,1), San Antonio (0.66,1), San José (0.66,1), Hobart (0.66,0), Bologna (0.66,0)	Canberra (1,1), Municipalidad de Peñalolén (1,1), Municipalidad de San José (1,1), Ayuntamiento de Hermosillo (1,1), Copenhagen (1,1), Ayuntamiento de Murcia (1,1), Bristol (1,1), Florence (1,1), Malmö Stad (1,1), Newcastle (1,1), Zürich (1,1), Boston (1,1), San Francisco (1,1), Cleveland (1,1), Columbus (1,1), Denver (1,1), Baltimore (1,1), Louisville.KY (1,1), San José (1,1), Washington D.C. (1,1)

In this logical minimization, * is a Boolean operator and stands for AND.

Solution pathway 1

The configurations given in table 7 show the solution pathways. The first solution shows that when there is high collaboration (condition 1) and up-to-date emission data (condition 3) it will result in the outcome with a consistency of 0,812 and a raw coverage of 0.537. Note that, due to contradictory configurations, two cases that are not part of the outcome also are included in the solution. These are Hobart and Bologna.

The consistency is high and backs up the empirical evidence, as this solution pathway to a considerable extent consistent even though the N-size of the research is quite high. The coverage, however, is lower, indicating that approximately half of the outcome can be explained by this solution pathway.

Coming back to the cases included in this solution pathway, these cities have high collaboration and up to data emission data. Going back to the literature, being a member of international city networks is shown to be beneficial for information gathering and knowledge sharing. There can be an effect between cities being part of a city network and therefore gaining the knowledge or the sense of urgency why up-to-date data is important. This solution pathway, however, does not say anything about the interaction between the two conditions, it shows that when both are present, the outcome is also present.

The unique coverage of this solution pathway is low (0.155). Unique coverage shows how much of the solution this pathway covers uniquely. This can be interpreted by stating that a large part of the outcome is explained by conditions other than the given pathway. So even though high collaboration and up-to-date data are sufficient for the outcome, also other factors play a role in explaining the variation in ambitious climate policy.

Solution pathway 2

The second solution pathway given in table 7 shows that when the mayor is left-wing oriented (condition 2) and the emission data is up to date (condition 3), it will result in the outcome with a consistency of 0,786 and a raw coverage of 0.687. In this solution, no cases without the outcome are included.

When the mayor of the city is left-wing oriented and the data is up to date, this is sufficient for the outcome. Left-wing oriented mayors can have more willingness or sense of urgency to see the importance of up-to-date data, and therefore have more ambitious climate targets.

The unique coverage of this solution pathway is higher than solution pathway 1 (0.3045), showing that more cases are uniquely covered by solution pathway 2, than solution pathway 1. However, still, a large part of the outcome remains unexplained by the pathways.

Interpretation of results

The truth table shows that high collaboration and up-to-date emission data or left-wing oriented mayor and up-to-date data are sufficient for the outcome. Relating back to the principles of complex causality, the two solution pathways show equifinality, as the combination of conditions lead to the same outcome. The separate solution pathways show conjunctural causality, as two conditions work together in causing the outcome.

The solution pathways found in logical minimization are not entirely in line with the expectation that all three conditions together would be sufficient for the outcome. The fact that up-to-date data is included in both pathways is not surprising, given that it also served as a necessary condition for the outcome. In addition, up-to-date data is important for setting climate targets because the ambitious climate targets foster more action and have more impact when they have a solid scientific background, a baseline, and a timeframe for cities to comply.

What is striking about this finding, however, is that the necessity of up-to-date data for climate target setting is not thoroughly assessed in the literature. While for setting achievable targets it seems obvious that data should be available and up to date, there is not much emphasis is on up-to-date data for urban climate policy in literature. Lacking data can hinder the construction of ambitious targets, while the QCA shows that up-to-date data is necessary for setting ambitious climate targets.

High collaboration was celebrated in literature to be an indicator for ambitious climate policy, especially membership to two or more international climate networks (Heikkinen et al., 2020). In the data matrix, the three cities with membership to all three international climate networks, Copenhagen, Miami, and Stockholm were also ambitious in their climate policy. However, high collaboration as a condition did not turn out to be sufficient on its own for ambitious climate policy in the logical minimization. A reasoning behind this can be that cities can have other drivers to become a member to international climate networks than ambition. Simply being a member of international climate networks does not oblige a city to act and set ambitious targets.

The presence of left-wing oriented mayors and high collaboration together did not show to be sufficient nor necessary for ambitious climate policy in terms of target setting. In addition, the calibration shows that there are also cities with right-wing mayors that have ambitious climate policies, like Miami and Stockholm. In the literature, some scholars showed that political orientation of mayors is not that strong of an indicator to predict whether a city is ambitious in its climate action (Hoff & Strobel, 2013). The cities Miami and Stockholm are celebrated in literature, for being extremely ambitious in their climate policy. Yet, their mayor is right-wing oriented, which can imply that, at least for these two cases, the drive for ambitious climate policy does not come from political orientation of the mayor. However, looking at the large case selection, political orientation of the mayor does, in combination with up-to-date data, in many instances lead to more ambitious climate ambition.

Another explanation is that the fact that a city is part of an international climate network does not have to do with the mayor or the political orientation of the mayor. Drivers for joining international climate networks are often related to information and knowledge sharing, how globalized a city is and how connected a city is to other cities.

An alternative explanation is that climate policy ambition is a longer process than the period the person who is the mayor is in power. Policies have a longer timeframe than the time the current mayor is governing, and when the mayor changes, that does not automatically mean that the city is not part of international climate networks anymore. In addition, for cities there are many benefits from joining action networks, besides the network and knowledge sharing. For instance, being a member of a climate network is also good for the status and power of a city. These drivers do not necessarily relate to the political orientation of the mayor.

Another explanation relates to the fact that left- or right-wing ideology in general does not dictate the course of action and underlying drivers of local city governments. While for some cities it might be true that the political orientation of the local mayor changes the course of action, it is more likely that mayors focus on what is needed for the city and its inhabitants.

Discussion

Limitations

Although the fsQCA performed in this research offered an interesting perspective into what pathways lead to variation in the ambition of climate policy of cities, some limitations are reported. Limitations relate to QCA as a research method itself, the gathered data, and possible biases. In addition, a robustness check is done.

First, QCA as a research method does not offer the reasoning behind the pathways found, rather offering insights into what a possible causal pathway can be. Despite of this, QCA shows a possible pathway leading to a possible explanation of variation in climate policy ambition in terms of target setting. Thereby, offering argumentation for causal pathways leading to the outcome.

Second, as QCA does not allow missing data, data gathering has limitations. Because of the iterative nature of QCA, conditions or cases are omitted to maintain a valid dataset. Yet, because the cities (cases) are located all over the world, not all data was available or accessible due to language barriers. This lacking data led to leaving out a fourth condition derived from literature - administrative capacity. Insights into administrative capacity would have given an interesting and not much-researched perspective into cases and the research question.

Likewise, the lack of data can lead to selection bias. Data collection showed that cities that are part of the outcome – ambitious cities – had more data available and generally were more transparent. On the other hand, gathering data from cities that were not ambitious cities in terms of target setting was harder as data was less available. The data bias can have several reasons. For instance, larger cities that have more resources can thereby also have more capacity to make their data available. Besides, ambitious cities in terms of target setting can have more willingness to disclose their data as they are more willing to act in the first place.

The up-to-date data condition was also subject to data collection bias. The criterion for up-to-date data was the emission data disclosed to CDP. However, the cities that did not disclose to CDP were scored with a 0. All the cities that were part of the CDP A list, and therefore labeled as ambitious cities, also disclosed their emission data, while the cities that were not part of the CDP A list and thereby not ambitious in their climate policy, were not automatically part of the CDP database. While a majority of the non-ambitious cities did disclose to CDP, yet did not have their emissions up-to-date, some did not disclose and therefore were scored with a 0. It is a possibility that some cities could have had their data published elsewhere, but did not disclose to CDP and thereby scored with a 0 in the dataset. However, most of the cities that have their data up-to-date are part of CDP, and it can be argued that when data of a city is up-to-date, they would disclose it to CDP. Therefore, this bias might not be very prominent and does not influence the outcome of the research to a considerable extent.

Another limitation is that translating data into fuzzy data or binary data reduces nuances and some information will get lost. While, in comparison to crisp data, fuzzy data does allow for more variation in the data, still assumptions have to be made. Gaining insights into where cases fall into the calibration, or even setting up calibration, calls for simplification of the data. However, simplification of data and reducing nuances also has upsides. What explains variation in city ambitious climate policy in terms of target setting is a complex matter. QCA offers a way to find underlying pathways in this complex system, and thereby allows researchers to get a grasp of the underlying causal directions.

The case selection following the criteria did lead to leaving out cities not from OECD countries, resulting in a higher representation of cities from the United States and Europe. Results of this QCA are only generalizable to cities that also fulfil the case selection criteria. Thereby, the results of this

QCA cannot be applied to cities outside OECD countries and will be more applicable to cities in Europe and the United States. However, the higher amount of cities within the United States and Europe does allow the results to be more generalizable to cities within these regions.

The conditions also imposed some limitations. First, choosing the conditions forces the researcher to leave out a great number of other possible factors. Only a limited amount of conditions is permitted in QCA, and given the time and scope of the research, more conditions would not have been feasible to research. However, more conditions could have given a more interesting pathway explaining variation in urban climate ambition. Second, setting up rules for calibration is subjective to the insights of the researcher. Therefore, to ensure generalizability, very general and straightforward rules had to be chosen. Where fsQCA makes it possible to portray data and cases in a more nuanced way, the rules of calibration were not very multi-interpretable. The upside is that this increased reliability of the research method. Third, for setting up conditions, assumptions had to be made, leading to simplification of reality.

An example of assumptions for conditions is the political orientation of mayors. In this research it was split into three options, left, middle/neutral/nonpartisan and right-wing oriented. However, this spectrum of left and right orientation of political parties and mayors is more complicated, and scholars have dedicated numerous studies to the topic. Also, political orientation of a mayor might not be as relevant for every single city. For example, some cities are more left-oriented in general, and therefore, a left-wing oriented mayor might not say too much about this specific city. Also, not all cities have elected mayors, therefore the orientation of the mayor might not be as representative of local citizens and overall willingness to act.

In this research, the focus was on governance factors explaining variation, however, other aspects of cities, such as physical and social aspects, can also explain (part of) variation in urban climate ambition. These physical and social aspects do relate to governance factors and therefore are worth mentioning in this discussion. More public awareness is important to increase public support, and when there is higher awareness, people tend to take more action (Drummond et al., 2018; Lee et al., 2015). More public awareness of climate change issues can lead, for example, to voting for a more left-wing local government, or more pressure on the local government to act. Related to public awareness is risk awareness. Risk awareness is increased when cities are located in areas with high climate risks (Lee & Painter, 2015). More risk awareness can lead to a higher sense of urgency for action, which can lead to more awareness that data collection is needed. Membership to international climate networks also comes with status and power, and cities with higher GDP can have a higher need for this (Reckien et al., 2015; Jänicke, 2005).

Robustness check

For checking the robustness, there are a few options mentioned in literature (Rutten, 2020, Schneider & Wagemann, 2012). First, the consistency threshold can be changed. In this research, a consistency threshold of 0.75 is used as recommended in literature. However, when the consistency threshold is raised to 0.80, the solution pathway that comes out of the analysis is the following: Cond_1_High_Collab*~Cond_2_Mayor_Pol*Cond_3_Uptodata with a consistency of 0,81 and a coverage of 0.22. This solution pathway shows that when high collaboration is present, and when the mayor is not left-oriented, and when the data is up to date, this will lead to the outcome. The two pathways found at a consistency threshold of 0.75 are excluded from this analysis, as their consistency in the logical minimization was too low. Even though the result from the higher consistency threshold is interesting, the coverage of this analysis is so low that this does not lead to sensible conclusions.

However, given the fact that the solution pathway changed when raised the consistency threshold does not speak in favor of the robustness of the conducted QCA.

Another robustness check is raising the frequency threshold of how many cases need to be included in the solution pathway. When the frequency threshold is increased from 1 to 5, this leads to not including the last three rows in the truth table. Raising the frequency threshold does not lead to different results, as the last three rows of the truth table were not sufficient for the outcome to begin with.

The last robustness check conducted is deleting random cases. Using SPSS, a random sample of 15% of the cases was selected (Adelaide, Copenhagen, Ayuntamiento de Murcia, Florence, Columbus, Baltimore, Wellington, Virginia Beach (VA), and Nashville (TN)). These cases were eliminated from the case selection, and a new analysis was conducted. This led to the same solution pathways as prior to the elimination, and similar coverage and consistency values. This shows that the cases sensitivity is low, and following the reasoning of Rutten (2020), the solution pathway given in the analysis is robust.

Theoretical implications

The research conducted in this study adds to the current body of literature with a moderately large N-study into governance aspects of variation in climate policy. Even though high collaboration was mentioned in literature to be a driver for more ambitious climate policy, this research shows the importance of the combination with up-to-date data. Also, as scholars were not as like-minded about whether political orientation matters, the current study gives argumentation that left-wing oriented mayors are more ambitious than right-wing mayors, especially in combination with up-to-date emission data.

The current research can also be used as a case selection for more in-depth research into what cities are lagging, and why they are lagging. Using the current study for case selection of lagging cities can defeat the 'frontrunner paradox' of too much emphasis on the frontrunners in climate action. When seeing the ambitious cities as the frontrunners, the QCA shows that there is also variation among the frontrunners. The current research shows more emphasis should be on the underlying reasoning and drivers for climate ambition rather than what the frontrunners are doing.

While this QCA focused on why there is variation in ambition, further research can use the conditions and combinations of conditions for making a more thorough distinction between which cities are ambitious and which cities are not. Gaining insights into which specific conditions and which specific cities are not ambitious or even unwilling in setting up climate targets can offer possibilities for directly focusing on these cities.

Another option for further research is doing another QCA but with a fuzzy set outcome. In the current QCA, the outcome was dichotomous (1 for ambitious and 0 for non-ambitious cities). This would identify a way to define whether a city is member of 'ambitious climate policy cities' and to what extent. In that case, for example the membership to international climate network scores can be used. Also, other indicators of ambitious cities already found in literature can be used to construct the ambitious outcome for climate policy. Then that can be used to test new conditions and see whether they are sufficient and which cities are ambitious and which are not.

Another interesting point for further research is more in-depth comparative case studies on cities part of the outcome and cities not part of the outcome. Due to time constraints a comparative case study was not included in this study, however, QCA offers great perspective on which cities to use for a case study.

Given that QCA is a rather new and not so commonly used research method, a parallel statistical analysis of the database could offer complementary insights into the data assessed. For example, a logistic regression could add to the research.

Further research could also use a smaller sample and research more conditions, or do multiple QCAs for the different aspects of a city: physical, social and governance. This can give insights into what aspect of a city is more influential in causing a city to be more ambitious in its climate policy.

Policy implications

The first advice for policy makers that follows from this research is that much more emphasis needs to be put on up-to-date data and data collection. As this research showed that up-to-date data is necessary for ambitious climate policy in terms of target setting, data collection can be the first step in mapping what is already done and what must be done. For constructing useful and achievable climate targets, data can guide local governments. For this research, emission data was used, however, data on any aspect of climate change can be useful in constructing specific targets for those areas. In addition, up-to-date data allows cities to track progress and change.

Another advice for policy makers is to use other cities as an example and make use of knowledge sharing via climate networks. While cities differ a lot, they can help each other, share knowledge, and have a greater impact on climate action.

Conclusion

This research began with gaining insights into what can be seen as 'ambitious' urban climate policy. Next cities were defined as actors interacting with other actors such as cities and governments as well as being able to make decisions on their own. The ambition of the urban climate policy of cities was measured in terms of target setting. From theory, three conditions derived for assessing whether they explain the variation in ambition of urban climate policy. The three conditions were high collaboration in climate networks, the left-wing oriented mayor, and up-to-date emission data. The case selection included 64 cities, of which half were considered ambitious in their climate policy and half are considered not ambitious. A fuzzy set qualitative comparative analysis was conducted to analyze which conditions or combinations of conditions were sufficient or necessary for producing ambitious climate policy in terms of target setting. Up-to-date data was found necessary for producing ambitious climate targets. High collaboration in combination with up-to-date data was found sufficient for producing the outcome. Likewise, left-wing oriented mayor in combination with up-to-date data was also found sufficient for producing ambitious climate targets.

This research was conducted to gain insights into the causal pathways of governance conditions explaining variation in ambitious urban climate policy in terms of target setting. To this extent this research attempted to answer the following research question:

What governance conditions explain the variation in the ambition of city climate policy in terms of target setting?

This research showed that explaining variation in climate policy ambition in terms of target setting consists of many variables. As cities differ in their location, their welfare, their structure, and their layout, cities also differ in their governance structure. Up-to-date data is shown to be necessary for producing the outcome, however, it does not explain the variation in why some cities set ambitious climate policies and some cities do not. Nevertheless, the necessity of up-to-date data does show that ambitious city climate policy cannot happen without up-to-date data. High collaboration in climate networks can give cities a boost and make them collect more data and show them the urgency to keep their data up-to-date, especially for target setting. Left-wing oriented mayors in combination with up-to-date data also show the possible pathway for the outcome. Therefore, at least some of the variation in the ambition of city climate policy in terms of target setting can be explained by the conditions assessed in this research. Moreover, the conditions up-to-date data and high collaboration imply that ambitious urban target setting cannot derive from a city on its own. Disclosing their data, making their emission data transparent and engaging in international climate networks offers cities the possibility to learn from each other. This is beneficial for the ultimate goal of the Paris Agreement and climate action in general; to battle climate change together.

To conclude, this research shows variation in urban climate policy exists because of the variation in up-to-date data, the extent to which cities are collaborating with climate networks, and the differences in the political orientation of the mayor.

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Appendix 1. Data cities with outcome

General data

Cities WITH outcome	Region	Country	Population size	Year of population size	what type?
Canberra	Oceania	Australia	420.960	2018	medium-size urban areas
Adelaide	Oceania	Australia	1.345.777	2018	metropolitan areas
Municipalidad de Peñalolén	Latin America & The Caribbean	Chile	241.599	2017	medium-size urban areas
Municipalidad de San José	Latin America & The Caribbean	Costa Rica	347.398	2020	medium-size urban areas
Ayuntamiento de Hermosillo	Latin America & The Caribbean	Mexico	919.332	2018	metropolitan areas
Copenhagen	European Union & Western Europe	Denmark	626.508	2019	metropolitan areas
Stockholm	European Union & Western Europe	Sweden	975.551	2018	large metropolitan area
Ayuntamiento de Murcia	European Union & Western Europe	Spain	450.220	2018	medium-size urban areas
Ayuntamiento de Vitoria-Gasteiz	European Union & Western Europe	Spain	250.475	2018	medium-size urban areas
BCP Council/Bournemouth	European Union & Western Europe	United Kingdom	532293	2018	metropolitan areas
Bristol	European Union & Western Europe	United Kingdom	955.541	2018	medium-size urban areas
Espoo	European Union & Western Europe	Finland	281.338	2018	medium-size urban areas
Helsinki	European Union & Western Europe	Finland	645.657	2018	metropolitan areas
Porto	European Union & Western Europe	Portugal	214.936	2018	medium-size urban areas

Florence	European Union & Western Europe	Italy	379.894	2018	medium-size urban areas
Torino	European Union & Western Europe	Italy	879.110	2018	metropolitan areas
Malmö Stad	European Union & Western Europe	Sweden	669.471	2018	metropolitan areas
Newcastle	European Union & Western Europe	United Kingdom	268.064	2018	medium-size urban areas
Zürich	European Union & Western Europe	Switzerland	1.384.728	2018	metropolitan areas
Boston	North America	United States	673.184	2016	metropolitan areas
Miami	North America	United States	453.579	2016	medium-size urban areas
San Francisco	North America	United States	870.887	2016	metropolitan areas
Cleveland	North America	United States	385.809	2016	medium-size urban areas
Columbus	North America	United States	860.090	2016	metropolitan areas
Denver	North America	United States	693.060	2016	metropolitan areas
Baltimore	North America	United States	614.664	2016	metropolitan areas
Louisville, KY	North America	United States	616.261	2016	metropolitan areas
San Antonio	North America	United States	1.469.845	2016	metropolitan areas
San José	North America	United States	1.025.350	2016	metropolitan areas
Washington D.C.	North America	United States	681.170	2016	metropolitan areas
Windsor	North America	Canada	354.917	2019	medium-size urban areas
Halifax Regional Municipality	North America	Canada	440.348	2019	medium-size urban areas

Data on population size from https://data.oecd.org/popregion/urban-population-by-city-size.htm
Type of city according to OECD city characterization https://data.oecd.org/popregion/urban-population-by-city-size.htm

Condition 1 - High Collaboration cities with outcome

Condition 1 High collaboration					
Cities WITH outcome	**C40**	**ICLEI**	**GCOM**	**How many yes?**	**Score**
CDP A list cities	Yes/No	Yes/No	Yes/No		
Canberra	no	No	Yes	1	0,33
Adelaide	no	Yes	Yes	2	0,66
Municipalidad de Peñalolén	no	No	Yes	1	0,33
Municipalidad de San José	no	No	Yes	1	0,33
Ayuntamiento de Hermosillo	no	No	No	0	0
Copenhagen	yes	Yes	Yes	3	1
Stockholm	yes	Yes	Yes	3	1
Ayuntamiento de Murcia	no	yes	Yes	1	0,33
Ayuntamiento de Vitoria-Gasteiz	no	Yes	Yes	2	0,66
BCP Council/Bournemouth	no	no	Yes	1	0,33
Bristol	no	yes	Yes	2	0,66
Espoo	no	yes	Yes	2	0,66
Helsinki	no	yes	Yes	2	0,66
Porto	no	no	Yes	1	0,33
Florence	no	yes	Yes	2	0,66
Torino	no	no	Yes	1	0,33
Malmö Stad	no	yes	Yes	2	0,66
Newcastle	no	no	Yes	1	0,33
Zürich	no	yes	Yes	2	0,66
Boston	yes	no	Yes	2	0,66
Miami	yes	Yes	Yes	3	1
San Francisco	yes	no	Yes	2	0,66
Cleveland	no	no	Yes	1	0,33
Columbus	no	yes	Yes	2	0,66
Denver	no	yes	Yes	2	0,66
Baltimore	no	yes	Yes	2	0,66
Louisville, KY	no	no	Yes	1	0,33
San Antonio	no	yes	Yes	2	0,66
San José	no	yes	Yes	2	0,66
Washington D.C.	no	no	Yes	1	0,33
Windsor	no	no	Yes	1	0,33
Halifax Regional Municipality	no	no	Yes	1	0,33

Condition 2 – Left wing local government

Condition 2 Left wing local government			
Cities WITH outcome			political orientation
CDP A list cities	Mayor name	political party of mayor	left/neutral/right
Canberra	Andrew Barr	Australian Labor Party (ACT Branch)	left
Adelaide	Sandy Verschoor	nonpartisan	independent
Municipalidad de Peñalolén	Carolina Leitao	Christian Democratic Party	left
Municipalidad de San José	Johnny Araya Monge	National Liberation Party	left
Ayuntamiento de Hermosillo	Célida López Cárdenas	Morena	left
Copenhagen	Frank Jensen	Social Democracts	left
Stockholm	Anna König Jerlmyr	The Moderate Party	right
Ayuntamiento de Murcia	José Antonio Serrano Martínez	PSOE	left
Ayuntamiento de Vitoria-Gasteiz	Gorka Urturan	EAJ-PNV	right
BCP Council/Bournemouth	David Kelsey	Conservative	right
Bristol	Marvin Rees	Labour	left
Espoo	Jukka Mäkelä	National Coalition Party	right
Helsinki	Jan Vapaavuor	National Coalition Party	right
Porto	Rui Moreira	nonpartisan	independent
Florence	Dario Nardella	PD	left
Torino	Chiara Appendino	M5S	middle
Malmö Stad	Katrin Stjernfeldt Jammeh	Social Democracts	left
Newcastle	David Cook	Labour	left
Zürich	Corine Mauch	Social Democratic Party of Switzerland (SP)	left
Boston	Kim Janey	Democrat	left
Miami	Francis X. Suarez	Republican	right
San Francisco	London Breed	Democrat	left
Cleveland	Frank G. Jackson	Democrat	left
Columbus	Andrew Ginther	Democrat	left
Denver	Micheal Hancock	Democrat	left
Baltimore	Brandon Scott	Democrat	left
Louisville, KY	Greg Fischer	Democrat	left
San Antonio	Ron Nirenberg	nonpartisan	independent
San José	Sam Liccardo	Democrat	left
Washington D.C.	Muriel Bowser	Democrat	left
Windsor	Andrew Dilkens	nonpartisan	independent

Halifax Regional Municipality	Mike Savage	nonpartisan	independent

Condition 3 – Up to date emission data

Condition 3 Up-to-date emission data		
Cities WITH outcome	Up to date	
CDP A list cities	Yes/No	score
Canberra	yes	1
Adelaide	yes	1
Municipalidad de Peñalolén	yes	1
Municipalidad de San José	yes	1
Ayuntamiento de Hermosillo	yes	1
Copenhagen	yes	1
Stockholm	yes	1
Ayuntamiento de Murcia	yes	1
Ayuntamiento de Vitoria-Gasteiz	yes	1
BCP Council/Bournemouth	yes	1
Bristol	yes	1
Espoo	yes	1
Helsinki	yes	1
Porto	yes	1
Florence	yes	1
Torino	yes	1
Malmö Stad	yes	1
Newcastle	yes	1
Zürich	yes	1
Boston	yes	1
Miami	yes	1
San Francisco	yes	1
Cleveland	yes	1
Columbus	yes	1
Denver	yes	1
Baltimore	yes	1
Louisville, KY	yes	1
San Antonio	yes	1
San José	yes	1
Washington D.C.	yes	1
Windsor	yes	1
Halifax Regional Municipality	yes	1

Appendix 2 – Cities without outcome

General data

Cities without outcome					
	Region	**Country**	**Population size**	**Year of population size**	**what type?**
Wellington	Oceania	New Zealand	418.500	2017	medium-size urban area
Hobart	Oceania	Australia	232.606	2018	medium-size urban area
Vina del Mar	Latin America & The Caribbean	Chile	361.371	2020	medium-size urban area
Tepic	Latin America & The Caribbean	Mexico	507.927	2020	metropolitan area
Saltillo	Latin America & The Caribbean	Mexico	997.913	2020	metropolitan area
Aarhus	European Union & Western Europe	Denmark	345.635	2019	medium-size urban area
Gothenburg	European Union & Western Europe	Sweden	579.281	2018	metropolitan area
Córdoba	European Union & Western Europe	Spain	358.510	2018	medium-size urban area
Pamplona	European Union & Western Europe	Spain	200.359	2018	medium-size urban area
Glasgow	European Union & Western Europe	United Kingdom	598.830	2018	metropolitan area
Liverpool	European Union & Western Europe	United Kingdom	496.784	2018	medium-size urban area
Stuttgart	European Union & Western Europe	Germany	634.830	2019	metropolitan area
Nantes	European Union & Western Europe	France	633.690	2015	metropolitan area
Montpellier	European Union & Western Europe	France	428.909	2015	medium-size urban area

Palermo	European Union & Western Europe	Italy	665.903	2018	metropolitan area
Bologna	European Union & Western Europe	Italy	389.948	2018	medium-size urban area
Debrecen	European Union & Western Europe	Hungary	265.646	2018	medium-size urban area
Plymouth	European Union & Western Europe	United Kingdom	234.982	2018	medium-size urban area
Geneve	European Union & Western Europe	Switzerland	597.269	2018	metropolitan area
El Paso (TX)	North America	United States	683.080	2016	metropolitan area
Virginia Beach (VA)	North America	United States	452.602	2016	medium-size urban area
Indianapolis (IN)	North America	United States	855.164	2016	medium-size urban area
New Orleans (LA)	North America	United States	391.495	2016	medium-size urban area
Charlotte (NC)	North America	United States	842.051	2016	metropolitan area
Fort Worth (TX)	North America	United States	854.113	2016	metropolitan area
Jacksonville (FL)	North America	United States	880.619	2016	metropolitan area
Omaha (NE)	North America	United States	446.970	2016	medium-size urban area
Tampa (FL)	North America	United States	377.165	2016	medium-size urban area
Mesa (AZ)	North America	United States	484.587	2016	medium-size urban area
Nashville (TN)	North America	United States	638.367	2016	metropolitan area
Oshawa	North America	Canada	413.936	2019	medium-size urban area
Victoria	North America	Canada	402.271	2019	medium-size urban area

Condition 1 – High collaboration

Condition 1 High collaboration					
Cities WITHOUT outcome	C40	ICLEI	GCOM	How many yes?	Score
	Yes/No	Yes/No	Yes/No		
Wellington	no	no	yes	1	0,33
Hobart	no	yes	yes	2	0,66
Vina del Mar	no	no	no	0	0
Tepic	no	no	no	0	0
Saltillo	no	yes	no	1	0,33
Aarhus	no	no	yes	1	0,33
Gothenburg	no	yes	yes	2	0,66
Córdoba	no	no	yes	1	0,33
Pamplona	no	no	yes	1	0,33
Glasgow	no	yes	yes	2	0,66
Liverpool	no	no	yes	1	0,33
Stuttgart	no	no	yes	1	0,33
Nantes	no	yes	yes	2	0,66
Montpellier	no	yes	yes	2	0,66
Palermo	no	no	yes	1	0,33
Bologna	no	yes	yes	2	0,66
Debrecen	no	no	yes	1	0,33
Plymouth	no	no	no	0	0
Geneve	no	no	yes	1	0,33
El Paso (TX)	no	no	no	0	0
Virginia Beach (VA)	no	no	no	0	0
Indianapolis (IN)	no	no	no	0	0
New Orleans (LA)	yes	no	yes	2	0,66
Charlotte (NC)	no	no	yes	1	0,33
Fort Worth (TX)	no	no	no	0	0
Jacksonville (FL)	no	no	yes	1	0,33
Omaha (NE)	no	no	no	0	0
Tampa (FL)	no	no	yes	1	0,33
Mesa (AZ)	no	no	no	0	0
Nashville (TN)	no	yes	yes	2	0,66
Oshawa	no	no	no	0	0
Victoria	no	yes	yes	2	0,66

Condition 2 – Left wing local government

Condition 2 Left wing local government				
Cities WITHOUT outcome			political orientation	
	Mayor name	political party of mayor	left/neutral/right	score
Wellington	Andy Foster	New Zealand First	middle	0,33
Hobart	Anna M. Reynolds	nonpartisan	neutral	0,33
Vina del Mar	Macarena Ripamonti Serrano	Democratic Revolution	left	1
Tepic	Francisco Javier Castellón Fonseca	PRD	left	1
Saltillo	Manolo Jimenez Salinas	Institutional Revolutionary Party	middle	0,33
Aarhus	Jacob Bundsgaard Johansen	Social Democrats	left	1
Gothenburg	Axel Josefson	Moderate Party	right	0
Córdoba	José María Bellido	PP	right	0
Pamplona	Enrique Maya	Navarra Suma	right	0
Glasgow	Philip Braat	Labour	left	1
Liverpool	Joanne Anderson	Labour	left	1
Stuttgart	Fritz Kuhn	Alliance 90/The Greens	left	1
Nantes	Johanna Rolland	Socialist Party	left	1
Montpellier	Michaël Delafosse	Socialist Party	left	1
Palermo	Leoluca Orlando	Demcratic Party	left	1
Bologna	Virginio Merola	Democratic Party	left	1
Debrecen	László Papp	Fidesz	right	0
Plymouth	Terri Beer	Conservative	right	0
Geneve	Frédérique Perler	The Greens	left	1
El Paso (TX)	Oscar Leeser	Democrat	left	1
Virginia Beach (VA)	Bobby Dyer	Republican	right	0
Indianapolis (IN)	Joe Hogsett	Democrat	left	1
New Orleans (LA)	LaToya Cantrell	Democrat	left	1
Charlotte (NC)	Vi Lyles	Democrat	left	1
Fort Worth (TX)	Mattie Parker	Republican	right	0
Jacksonville (FL)	Lenny Curry	Republican	right	0
Omaha (NE)	Jean Stothert	Republican	right	0
Tampa (FL)	Jane Castor	Democrat	left	1
Mesa (AZ)	John Giles	Republican	right	0
Nashville (TN)	John Cooper	Democrat	left	1
Oshawa	Dan Carter	nonpartisan	neutral	0,33
Victoria	Lisa Helps	nonpartisan	neutral	0,33

Condition 3 – Up to date emission data

Condition 3 Up-to-date emission data		
Cities WITHOUT outcome	Up to date	
	Yes/No	score
Wellington	yes	1
Hobart	yes	1
Vina del Mar	no	0
Tepic	no	0
Saltillo	no	0
Aarhus	no	0
Gothenburg	no	0
Córdoba	no	0
Pamplona	no	0
Glasgow	no	0
Liverpool	no	0
Stuttgart	no	0
Nantes	no	0
Montpellier	no	0
Palermo	no	0
Bologna	yes	1
Debrecen	no	0
Plymouth	yes	1
Geneve	no	0
El Paso (TX)	no	0
Virginia Beach (VA)	no	0
Indianapolis (IN)	yes	1
New Orleans (LA)	yes	1
Charlotte (NC)	yes	1
Fort Worth (TX)	no	0
Jacksonville (FL)	no	0
Omaha (NE)	yes	1
Tampa (FL)	no	0
Mesa (AZ)	no	0
Nashville (TN)	yes	1
Oshawa	no	0
Victoria	yes	1

Appendix 3. Truth table analysis

****
TRUTH TABLE ANALYSIS
****

File: C:/Users/6966977/Documents/THE RIGHT database for analysis.csv
Model: Outcome = f(Cond_1_High_Collab, Cond_2_Mayor_Pol, Cond_3_Uptodata)
Algorithm: Quine-McCluskey

--- COMPLEX SOLUTION ---
frequency cutoff: 1
consistency cutoff: 0.761349
raw unique
coverage coverage consistency
---------- ---------- ----------
Cond_1_High_Collab*Cond_3_Uptodata 0.537187 0.155312 0.812766
Cond_2_Mayor_Pol*Cond_3_Uptodata 0.686875 0.305 0.785842
solution coverage: 0.842187
solution consistency: 0.802083

Cases with greater than 0.5 membership in term Cond_1_High_Collab*Cond_3_Uptodata:
Copenhagen (1,1),
Stockholm (1,1), Miami (1,1), Adelaide (0.66,1),
AyuntamientodeVitoria-Gasteiz (0.66,1), BristolCityCouncil (0.66,1), Espoo (0.66,1),
Helsinki (0.66,1), Florence (0.66,1), MalmöStad (0.66,1),
Zürich (0.66,1), Boston (0.66,1), SanFrancisco (0.66,1),
Columbus (0.66,1), Denver (0.66,1), Baltimore (0.66,1),
SanAntonio (0.66,1), SanJosé (0.66,1), Hobart (0.66,0),
Bologna (0.66,0)
Cases with greater than 0.5 membership in term Cond_2_Mayor_Pol*Cond_3_Uptodata:
Canberra (1,1),
MunicipalidaddePeñalolén (1,1), MunicipalidaddeSanJosé (1,1), AyuntamientodeHermosillo (1,1),
Copenhagen (1,1), AyuntamientodeMurcia (1,1), BristolCityCouncil (1,1),
Florence (1,1), MalmöStad (1,1), NewcastleCityCouncil (1,1),
Zürich (1,1), Boston (1,1), SanFrancisco (1,1),
Cleveland (1,1), Columbus (1,1), Denver (1,1),
Baltimore (1,1), Louisville.KY (1,1), SanJosé (1,1),
WashingtonD.C. (1,1)
****

TRUTH TABLE ANALYSIS
****

File: C:/Users/6966977/Documents/THE RIGHT database for analysis.csv
Model: Outcome = f(Cond_1_High_Collab, Cond_2_Mayor_Pol, Cond_3_Uptodata)
Algorithm: Quine-McCluskey

--- PARSIMONIOUS SOLUTION ---
frequency cutoff: 1
consistency cutoff: 0.761349
raw unique
coverage coverage consistency
---------- ---------- ----------
Cond_1_High_Collab*Cond_3_Uptodata 0.537187 0.155312 0.812766
Cond_2_Mayor_Pol*Cond_3_Uptodata 0.686875 0.305 0.785842
solution coverage: 0.842187
solution consistency: 0.802083

Cases with greater than 0.5 membership in term Cond_1_High_Collab*Cond_3_Uptodata:
Copenhagen (1,1),
Stockholm (1,1), Miami (1,1), Adelaide (0.66,1),
AyuntamientodeVitoria-Gasteiz (0.66,1), BristolCityCouncil (0.66,1), Espoo (0.66,1),
Helsinki (0.66,1), Florence (0.66,1), MalmöStad (0.66,1),
Zürich (0.66,1), Boston (0.66,1), SanFrancisco (0.66,1),
Columbus (0.66,1), Denver (0.66,1), Baltimore (0.66,1),
SanAntonio (0.66,1), SanJosé (0.66,1), Hobart (0.66,0),
Bologna (0.66,0)
Cases with greater than 0.5 membership in term Cond_2_Mayor_Pol*Cond_3_Uptodata:
Canberra (1,1),
MunicipalidaddePeñalolén (1,1), MunicipalidaddeSanJosé (1,1), AyuntamientodeHermosillo (1,1),
Copenhagen (1,1), AyuntamientodeMurcia (1,1), BristolCityCouncil (1,1),
Florence (1,1), MalmöStad (1,1), NewcastleCityCouncil (1,1),
Zürich (1,1), Boston (1,1), SanFrancisco (1,1),
Cleveland (1,1), Columbus (1,1), Denver (1,1),
Baltimore (1,1), Louisville.KY (1,1), SanJosé (1,1),
DistrictofColumbia/WashingtonD.C. (1,1)
****
TRUTH TABLE ANALYSIS
****

File: C:/Users/6966977/Documents/THE RIGHT database for analysis.csv

Model: Outcome = f(Cond_1_High_Collab, Cond_2_Mayor_Pol, Cond_3_Uptodata)
Algorithm: Quine-McCluskey

--- INTERMEDIATE SOLUTION ---
frequency cutoff: 1
consistency cutoff: 0.761349
Assumptions:
Cond_1_High_Collab (present)
Cond_2_Mayor_Pol (present)
Cond_3_Uptodata (present)
raw unique
coverage coverage consistency
---------- ---------- ----------
Cond_1_High_Collab*Cond_3_Uptodata 0.537187 0.155312 0.812766
Cond_2_Mayor_Pol*Cond_3_Uptodata 0.686875 0.305 0.785842
solution coverage: 0.842187
solution consistency: 0.802083

Cases with greater than 0.5 membership in term Cond_1_High_Collab*Cond_3_Uptodata:
Copenhagen (1,1),
Stockholm (1,1), Miami (1,1), Adelaide (0.66,1),
AyuntamientodeVitoria-Gasteiz (0.66,1), BristolCityCouncil (0.66,1), Espoo (0.66,1),
Helsinki (0.66,1), Florence (0.66,1), MalmöStad (0.66,1),
Zürich (0.66,1), Boston (0.66,1), SanFrancisco (0.66,1),
Columbus (0.66,1), Denver (0.66,1), Baltimore (0.66,1),
SanAntonio (0.66,1), SanJosé (0.66,1), Hobart (0.66,0),
Bologna (0.66,0)
Cases with greater than 0.5 membership in term Cond_2_Mayor_Pol*Cond_3_Uptodata:
Canberra (1,1),
MunicipalidaddePeñalolén (1,1), MunicipalidaddeSanJosé (1,1), AyuntamientodeHermosillo (1,1),
Copenhagen (1,1), AyuntamientodeMurcia (1,1), BristolCityCouncil (1,1),
Florence (1,1), MalmöStad (1,1), NewcastleCityCouncil (1,1),
Zürich (1,1), Boston (1,1), SanFrancisco (1,1),
Cleveland (1,1), Columbus (1,1), Denver (1,1),
Baltimore (1,1), Louisville.KY (1,1), SanJosé (1,1),
DistrictofColumbia/WashingtonD.C. (1,1)