Transnational Municipal Networks not a panacea:

A mixed methods study on C40 Cities climate initiative

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MASTER OF SCIENCE THESIS

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by

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Executive summary

Cities have been acknowledged as the critical actors in the context of climate change as they account for nearly 70% of the global CO_2 emissions. Mayors and municipalities understand the urgency needed with the climate action and are acting at the forefront by engaging in transnational initiatives to support emissions reductions. The steady emergence of transnational municipal networks such as C40 or ICLEI is an indication of a paradigm shift in climate change governance. These TMNs have started to become diplomatic actors themselves and fostering climate action within the network.

The existing literature on the role of climate network(s) remains fragmented and lack continuous assessment on the impact of network membership on emissions. Due to variation in TMNs structure, history, functionality and more, the complex dynamics of the network makes it difficult to generalise the role of membership in the translation of activities and resources into measurable outcomes. To fill this gap, I adopt a multi-disciplinary approach to explore the relationship of network membership on climate mitigation as a measure of change in CO_2 emissions. To address the knowledge gap, this research is focused on a single TMN i.e., the C40 cities network and the main research question is formulated as follows:

> *"What is the impact of C40 cities network membership in selected OECD cities on climate mitigation?"*

To answer the research question, two complementary research approaches are used; a statistical analysis to empirically establish the relation of network membership with the CO_2 emissions, and a qualitative cross-case analysis to unpack how and where C40 is effective with regard to my integrated research framework. Before the analysis, the research begins with explaining the broader literature related to climate change and TMNs, followed by analysing the C40 network to establish an understanding of the governance structure and the potential of the network activities. The empirical analysis combines the use of geospatial data on CO_2 emissions with temporal coverage from 2001-19, to mitigate the existing barriers in using the self-reported data on emissions. I analysed data from 650 OECD cities, entailing 41 C40 members, out of a total of 97 members within the network. Multi-variate regression

is performed to find the significance of C40 network membership on the dependent variable i.e., the % change in CO_2 emissions. Total 7 models were prepared and the model with all the predictors explained the most variance i.e 55 %. The network membership had no significant statistical relationship with the decrease in emissions. Besides that, the analysis provides empirical evidence on the governance indicators impact as cities with higher government effectiveness were able to reduce emissions by 2.2% per year. Also, the higher degree of decentralisation within a country is associated with a decrease in emissions. GDP as a proxy for resource availability and consumption is relatively more significant in the Large metropolitan areas. Furthermore, the case selection in qualitative analysis is based on the quantitative findings.

The two selected cases are; Copenhagen and Bogotá. Both represent significant diversity to capture the variation in terms of motivation, capacities, socio-political landscape and support from C40. A research framework was synthesized by combining concepts from two existing research frameworks in academia to analyze the C40's intervention concerning climate mitigation. The framework's utility is in identifying the causality of C40 membership on various indicators and establishing the similarities and differences in the case studies. To account for any undocumented information regarding C40's work with municipalities and its impact, comprehensive qualitative interviews was conducted with the municipalities, C40 staff and researchers in academia. The analysis showed the C40's direct intervention is limited to increasing or maintaining the ambition of cities and the intra-municipal factors. However, no relationship could be established with the implementation of plans and policies within the network. Financial, institutional and political barriers such as misalignment of national and local government, laws around climate change, etc. are some of the challenges that cities face in taking climate action.

This thesis examined the case of the C40 network, and the triangulation of results suggest that no causality can be determined between network membership and CO_2 emissions in the OECD cities. The biggest selling point of C40 is its legitimate financial capacity and political diplomacy. However, it is too simplistic to say that the motivation for cities participating is either for symbolic reasons or socio-logical reasoning. The motivation differs significantly within the municipal departments and changes with time and political power. The potential of C40 is huge, but cannot deliver until collective action is achieved where the national government needs to provide financial assistance to the cities, cities need to collaborate with private stakeholders and citizens and C40 needs to orchestrate the circus. The lack of translation of ambition leads to missing out on the transformation and creates "leaders" and "laggards" within the network, such was the case in Copenhagen and Bogotá. I argue that the efficacy of C40 lies in bridging this gap within their network. This analysis is the first approximation for singling out the role of network membership and further research is needed to validate my findings.

Ideally, repeating the same analysis after some time would be beneficial, with the better inputs such as granular data on C40, joining year of members, more shapefiles beyond OECD, etc. Moreover, more case studies are needed to generalise my findings specifically in the global south. And lastly, policy researchers need to investigate the role TMNs in the implementation of climate action plans and how cities can bypass the barriers which hinder their progress against climate change.

Acknowledgements

This thesis marks the end of my journey as a CoSEM student at the Delft University of Technology. The journey so far has been challenging, rewarding but most importantly, humbling. It gives me immense joy to finally present my hard work of two years and acknowledge all the people who helped me to make this a reality.

First and foremost, I would like to thank my family for their unconditional love, support and belief in me. I would not have made it this far in life without them and all my accomplishments are their accomplishments as well. I would like to thank Prof.dr. Kornelis Blok and Dr. Thomas Hoppe for believing in my research proposal and providing critical feedback along the journey. I want to express my sincerest gratitude to Dr. Nihit Goyal for our weekly discussions and constant support throughout the thesis. Thank you for setting time to provide critical feedback on my work, which helped in finishing the thesis. I would also like to express my gratitude to all my interview subjects for allowing me the opportunity to conduct my investigation, in times when I was getting no responses and people were not interested in my research.

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Delft, University of Technology   Chitransh Lot
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Glossary

CFF	C40 Finance Facility
CAP	Climate Action Plan
CoSEM	Complex Systems Engineering and Management
GHG	Greenhouse Gases
UNFCC	United Nations Framework Convention on Climate Change
NSA	Non State Actor
TMN	Transnational Municipal Network
GIS	Geographic Information System
ICLEI	International Council for Local Environmental Initiatives
SDG	Sustainable Development Goal
IPCC	Intergovernmental Panel on Climate Change
GDP	Gross Domestic Product
ODIAC	Open-source Data Inventory for Anthropogenic CO_2
FUA	Functional Urban Area
RAI	Regional Authority Index
HDD	Heating Degree Days
CDD	Cooling Degree Days
OECD	Organisation for Economic Co-operation and Development
CARMA	Carbon Monitoring for Action & Maintenance
CIFF	Children's Investment Fund Foundation

Chapter 1

Introduction

1.1 Problem Background

Climate change is leading to profound changes in the Earth system such as changes in ice cover, forest fires, rising sea levels and extreme events. Preventing climate change calls for an immediate action which with ongoing historical emissions and the long timescales would require both mitigation and adaption to climate change at a local level [11]. Globally, a shift towards a bottom-up approach to climate actions is recognized which is reflected in the emergence of non-state actors (NSA) such as cities leading the climate change mitigation [12]. The consensus is that the private sector could be more efficient in implementing climate change mitigation and adaptations, however, climate initiatives have predominantly focus on the public sector and not on the private sector or citizens [13]. The emergence of the number of transnational governance initiatives or also known as, non-state initiatives have been complementing the traditional intergovernmental organisation such as the World Bank, United Nations Framework Convention on Climate Change (UNFCCC), etc. in the world of climate action [14]. These non-state initiatives can be defined as the initiatives driven by subnational actors, which broadly include cities, regions, companies, NGOs, where central governments do not have complete jurisdiction upon.

With GHG emissions continue to rise, despite scientific warnings and political commitments [15], it is critical at this stage to re-evaluate the role of not only the national government in climate mitigation, but also of companies, cities and other agents which were acknowledged as important actors in the Paris Agreement. These actors have become very critical for climate actions owing to the increase in the number of non-state initiatives. The UNEP Emissions Gap report 2019 [15] tracks down that regardless of whether all the Nationally Determined Contributions (NDCs) under the Paris agreement is carried out, we are yet on a course for a 3.2°C temperature rise, in opposition to planned 1.5°C limits. The slow pace of international agreements have shifted the attention on initiatives focusing on non-state actors, like cities that can implement both mitigation and adaptation policies efficiently [16, 17] and provides the ground to test experimental governance at meeting local climate objectives with different

purposes and outcomes [18, 19]. From the Paris Agreement, thousands of cities and companies have committed themselves to the mission towards climate neutrality and have made commitments towards setting increasing renewable energy deployment, committing to reduction targets and financing for energy efficiency and other innovative technology upgrades [20] through various transnational networks. These transnational networks foster participation among cities as they engage with other actors and pool their worldwide impact as pressing climate action actors [21], however, limited research exists on the progress made and the influence of these transnational networks on urban emissions.

1.1.1 Why cities?

Over half of the global population resides in cities and the proportion is expected to increase to 68% by 2050 [22]. Given that, cities are also accountable for over 70% of global CO_2 emissions as they concentrate most economic activity, infrastructure, people and emissions from energy [23]. As urbanisation tends to continue, cities with high population are becoming vulnerable to climate externalities caused by emissions. The Paris Agreement of the United Nations Framework Convention on Climate Change [24] distinguishes "civil society, the private sector, financial institutions, cities and other subnational authorities" (p. 19) as critical actors responding to climate change. Castán Broto [25] argues that cities play a vital role in the transnational governance of climate change in three ways: "first and foremost, cities support cycles of learning and trade between nearby governments and other sub-public associations. Also, they accumulate nearby assets and information to carry out explicit plans. Thirdly, by raising the profile of cities in global plans, they summon the interest of political and business stakeholders." The popularity of transnational municipal climate networks (TMCN) has been unprecedented and quite possibly represents one of the most ubiquitous forms of transnational climate change governance [26, 18, 25]. The emergence of transnational municipal networks (TMN) is a recent phenomenon, started in the late 1980s and is associated with to, raise the global strategy plans, (for example, climate change) and to the internationalization measures that have followed more extensive cycles of globalization and neoliberal belief systems [27]. Not only TMNs boasts of high ambition, academic and policymakers also described cities as "the new climate leader" [28, 29].While it is obvious to assume the important role cities have in addressing climate change, what remains undeniably less understood is the impact of translation of climate change discourses on metropolitan emissions.

1.1.2 Why C40 Cities climate network?

There is a spectrum of active climate networks currently which differs strongly on how they were formed and what goal they are trying to achieve. In order to understand the role of the city's in addressing the gaps left by national governments in climate governance, the transnational initiative of C40 cities climate leadership group will be the focus of this research, hereafter referred to as C40. C40 is a means to study and comprehend the role of TMNs in climate change politics.

C40 started as a parallel initiative to the G8 summit on climate change in 2005 [26] which is financed by philanthropies such as Bloomberg Philanthropies, the Children's Investment Fund Foundation and Realdania. Additional funding comes from partners such as IKEA,

Arup consultancy, UK government, the Clinton Foundation, etc. [30]. It is a network of municipalities or more precisely, the representatives of the municipalities, with a common mission stated as: "C40 is a global network of large cities taking action to address climate change by developing and implementing policies and programs that generate measurable reductions in both greenhouse gas emissions and climate risks" [31].

C40 has attracted a lot of attention both politically and in academia, and is leading this new wave of transnational climate governance by addressing climate change issues at conferences, publications and award ceremonies. The unique thing about C40 is that it is not a membership organisation, rather the membership is merely on the invitation basis that has already proven their commitment to climate protection [32], hence it can be argued that C40 engages world's most influential city mayors and accelerates climate action by establishing a new paradigm of government collaboration [33]. At the time of writing, C40 holds 97 signatories spread across globally, majorly consisting of the world's megacities to address climate change. The exclusivity of the C40 network with limited set of members makes it interesting for the research standpoint, as the underlying hypothesis behind the selection is that small networks can potentially be more effective, due to specific focus and difficulty to get in and out of the network.

Despite the popularity and best intentions, several knowledge gaps remain regarding the nuances of the role played by TMN. The first knowledge gap concerns the motivation for participation for cities in the TMNs. In this research, C40 climate network will be analyzed in order to understand the rationale for participation in C40, and if the motivation differs between cities and also, if the cooperation is due to altruism or not? The second gap refers to the direct effect of network membership on emission reduction. Authors, such as Green [34] have criticise these climate networks in the light that these networks do little bit more than just greenwashing: they help cities committing to climate action, without actually reducing their emissions, which questions the legitimacy and effectiveness of the climate network owing to their fluid membership and voluntary participation. Third, how cities use the network membership is unclear and if or how the benefits are shared within the network?

1.2   Research objective and questions

The issue of measuring city-level emissions and quantifying the overall impact from TMN membership remains a challenging task [35, 36]. There is only one existing mixed-method research design in analysing the pure effect of network membership on climate mitigation and climate action plans of cities, performed Karhinen et al. [37] on the local climate network only in Finnish municipalities. Following the same approach, the research is aimed to single out the effect of a network membership of a high-profile international network such as C40, using a mixed-methods research design. The geographical scope of the research is limited to only selected OECD cities entailing both C40 and non C40 cities explained later in detail in subsection 1.3.2 . The main research question is formulated as follows:

"What is the impact of C40 cities network membership in selected OECD cities on climate mitigation?"

The main research question will be answered through answering the following three sub-research questions:

SQ1: What is C40 and what does its governance structure looks like?

SQ2: What are the measured impacts of C40 membership on climate mitigation?

SQ3: How does C40 membership affect municipal climate work and aid in climate mitigation?

1.3 Research Design

As mentioned, the research design entails a mixed-methods approach entailing two complementary approaches: qualitative and quantitative methods are used to answer the sub-questions. Before this, a literature review and desk research is conducted to conceptualise C40 and its governance structure, followed by establishing a hypothesis on the direction of network membership impact on climate mitigation. The research design entails a sequential approach, where quantitative analysis is conducted first, followed by qualitative analysis. The data is collected sequentially as well, in other words, findings from the qualitative analysis were used to explain the result from the quantitative analysis [38]. Both results hold equal status in the research and the triangulation of the quantitative and qualitative findings ensures the robustness of the results [39], which otherwise wouldn't have been sufficient with the individual methods.

By employing a sequential mixed methods design, it provides two main distinctive advantages for my research: first, it reduces the over-reliance on the statistical findings and second, the qualitative analysis helps in the interpretation of the quantitative results by providing in-depth insights into the mechanisms in place which cannot be captured in a quantitative model, therefore providing strong evidence(s) to make inferences with confidence. Additionally, inferences are made from whole mixed-method study instead of individual components of the research [40]. This section further elaborates on the chosen methods to answer the sub-questions, data requirements and lastly, the scope and limitations of the chosen methodology

1.3.1 Methodology

The sequential mixed methods design entails quantitative and qualitative streams to answer the sub-questions. The desk research on C40 is conducted first, to answer the SQ1. Articles are acquired from the extensive databases of Scopus and Web of Science. Only the relevant articles were considered for the report after controlling for citations and keywords. The grey literature was analyzed using C40 reports and case studies, articles and consultancy reports. The desk research ends with answering SQ1 and establishing a broad consensus on C40 and developing the hypothesis for further analysis. The quantitative analysis is conducted in the form of statistical analysis entailing a multi-variate regression model in line with answering SQ2. Followed by a cross-case analysis of cities to answer the SQ3. The detailed methodology

on both the methods is explained extensively in separate chapters: section 3.1 for statistical analysis and section 4.2 for qualitative analysis.

Regression analysis is one of the popular statistical methods in establishing an empirical relationship between the dependent variable and one or multiple independent variables [41]. In this research, multi-variate regression is used to quantify a statistical relationship between the C40 network membership and climate mitigation. A multivariate regression model is used for the hypothesis testing where the co-variates are defined using the literature review. GIS emission data is used from the ODIAC (Open-source Data Inventory for Anthropogenic CO2) [42] for CO_2 emissions and will be validated using the self-reported emissions of cities from CDP [43]. To have uniformity in the definition of city boundaries, the core functional urban areas of OECD cities [9] is selected to assess the emissions from each city. The rest of the data on covariates and data preparation is explained comprehensively in section 3.1.4. All the statistical tests were performed using R statistical programming environment (version 4.0.3).

To understand how and where the intervention from C40 is taking place in the municipalities in terms of taking climate-related actions and implementing sustainability policy, the case study design is selected to address this 'wicked problem' [44]. A cross-case analysis is performed using an integrative research framework synthesized from Hoppe et al. [6] and Hale et al. [5] frameworks. The cases are selected from the statistical analysis using the selection technique explained by *Seawright & Gerring* [45]. Considering the limited time duration of the thesis, the case selection is limited to only two cities: Copenhagen and Bogotá. Further, to understand the genuine circumstances within the selected cases, semi-formal interviews were conducted with civil servants, administrative members of C40, former city advisors and scientists with a research background in TMNs. All the interviews were conducted online using Zoom. The objective of the meeting was to investigate the non-reported data and acquire direct information on the ground level work by C40. The questions of the interview were based on different clusters of my research framework. In total, 6 interviews and 1 focus group was conducted. Secondary data is collected through reports, policy documents and scholarly literature. The interviews were qualitatively analysed using the research framework in Atlas.ti [46].

1.3.2 Scope

The sole focus of this research is on climate mitigation related activities of cities and C40 membership. The geographical scope of the research is limited to only selected OECD cities. This is due to time constraints and data available on the functional urban areas or city boundaries of OECD cities [9]. In the quantitative model, climate mitigation is measured in terms of average annual % change in emissions. It is to be noted that climate mitigation is not necessarily perceived as a reduction in emissions, but can also be interpreted in multiple ways, for instance, an increase in the deployment of solar or wind capacity, etc. However, in this research, only CO_2 emissions are taken into account which is also the primary driver of global climate change. In the qualitative research, it is to be noted that the analysis is not used to establish success or failure of the C40 network on the account of direct outcome i.e. change in emissions, rather exploring the relationship of network membership with different indicators of my research framework and explore where C40 intervention is effective. Also, the 'impact' may differ for case-to-case and change in emissions is only a partial measure for

it, as indirect benefits or outcomes from the network membership are out of the scope of this research.

1.3.3   Limitations of the methodology

Despite the advantages offered by mixed-method design, some key points need to be mentioned to ensure a valid interpretation of my results. As each study has its limitations, a mixed-method design is time-consuming and can be daunting for a single researcher considering the duration of the thesis. This poses questions on the rigour of both quantitative and qualitative research conducted and also the interpretation of mixing conflicting results. If poorly conducted, mixed methods research design may pose serious threat to the validity of results and reliability of the data collected and analysed. The first limitation is the sample analysed in the statistical analysis. There is a selection bias, as only selected OECD cities are used. This is due to the availability of clearly defined boundaries of the OECD cities as shapefiles that can be used with the GIS emissions data set. Another limitation is the information bias involved in interviewing people from the C40 organisation for the cross-case analysis. Moreover, due to time constraints and feasibility, the number of case studies has been limited to only two. To make robust judgments on the overall impact of C40, more case studies would be required to draw conclusions. Also, case study researches lack credibility on the efficiency of the selected method of the authors and the failure, to sum up, the examination discoveries to a more extensive level. Nonetheless, information move is conceivable in broader studies of TMNs and this research provides bases for future research to understand the single out the effect of TMN membership on climate mitigation.

1.4   Link with master programme

The thesis requirement for Complex Systems Engineering and Management (CoSEM) requires a multidisciplinary approach to design solutions at the interplay of technology, institutions, economics and citizens. This thesis captures the true essence of a multidisciplinary approach and highlights how CoSEM engineers can provide holistic solutions with their varied skillsets and generalist approach. The engagement of both public and private stakeholders and entities like climate networks makes it interesting from CoSEM perspective to gauge the intervention on the system and creating an understanding of the complex dynamics in the context of climate politics. The research has clear design elements in terms of both modelling and qualitative case studies and accounts for governance and institutions in place. All these study areas fall under the CoSEM programme, and the primary focus of the research also relates with my own track specialisation on energy and sustainability.

1.5   Thesis outline

The thesis is structured as follows:

- **Chapter 1** sketches the what, why and how of the thesis.

- **Chapter 2** begins with the broader literature on climate change and cities and defining key concepts in the context of climate networks. Then, scope shift towards conceptualising C40 in line with answering *SQ1*. The chapter is finished with developing the hypothesis for the analytical chapters.

- The statistical analysis presented in **Chapter 3** starts with the validation of the GIS data set, followed by the data preparation and results from the regression modelling.

- **Chapter 4** entails the qualitative analysis with the selected cases. The chapter begins by elaborating on the theoretical frameworks and their application in the context of this research. Cross-case analysis is performed and the findings are contemplated with the broader literature.

- **Chapter 5** reflects on the findings of *SQ2* and *SQ3* with the broader literature. I also highlight the limitations of my research and lists recommendations for future research.

- **Chapter 6** concludes the research, summarises the sub-question and answers the main research question. I finished the chapter with the advice for city, national government and C40 and reflecting on the academic relevance of my research.

Chapter 2

Background information

This chapter aims at providing the reader the context of the research and selected TMN case. First, the core concepts related with climate change such as climate mitigation and climate adaptation are explained. Specifically, this chapter explains the characteristics and emergence of the Transnational municipal climate network, followed by background of C40 cities and their governance structure, which is in line with answering the first sub question. The chapter will be concluded by formulating the hypothesis for the research, which will be analysed in the next chapter.

2.1 Cities and climate change

A lot of literature contemplates on the connection between the urban ares and climate change, including the negative externalities from climate change, the role of cities in climate change and the governance of cities related to climate issues [18]. Cities are key contributors towards climate change and accounts for nearly 80% of global CO2 emissions [47]. The compounded effects of climate change has put lot of communities on the verge of serious climate risks and often, cities are recognised as entities to offer potential solutions to curb the impacts of climate change. These solutions are often integrated as part of climate action plans (CAP) which are generally comprised of either/or climate change mitigation (CCM) or climate change adaptation (CCA) [48]. Mitigation is defined as per the IPCC as as "a human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs) [49]". Mitigation options are available in every major sector and can be more cost effective if an integrated approach is deployed which combines measures to reduce energy use and the greenhouse gas intensity of end-use sectors, decarbonize energy supply, reduce net emissions and enhance carbon sinks in land-based sectors. A broad range of mitigation approaches are available but two primarily mitigation options are low-carbon energy measures (Building integrated renewables, fuel switching to low-carbon fuels, etc) and energy saving measures (energy efficiency improvements, circularity, etc).

For years, cities and local municipalities network have existed, some focused at advocacy and multi issue cooperation and some on capacity building for urban sustainability and climate

change responses [50, 51]. In the context of global climate change responses, the emergence of partnerships and cooperation among local governments to address climate related issues, have been labelled as transnational municipal climate networks (TMNs; [51, 52]). These TMNs do not have any formal control over their signatories, other than enforcing responsibilities based on their membership conditions [53]. At present, however much remains unknown about the role of network participation beyond its functional aspect of collaboration. To what extent does network participation accelerates action at the municipal level and if, it results in more effective, additional and 'better' climate change responses and outcomes on the ground remains unclear.

2.1.1   Conceptualisation of climate action in cities

Mokhles and Davidson [54] listed three main functions of the climate action as part of TMNs: "1- they are purposive and strategic interventions with the aim of mitigation (reducing emissions of greenhouse gases) and/or adaptation (reducing the vulnerabilities to climate change impacts). 2- they have an experimental nature; they are collective trials, conducted through an iterative process of learning by doing and doing by learning through engaging different stakeholders. 3- they are associated with at least a city network. The city network's contribution could be facilitating the exchange of knowledge from one city to another, or assistance in partnership, financing, or technical support [55]." Cities look to legitimize their plans through TMNs to accelerate acceleration, as they can empower cities to take action through the exchange of 'best practises' [55], subsequently bypassing national government administration legitimizing their activities.

Cities climate actions plans typically revolve around four broad generic themes: energy; transport; urban planning; and waste management [56]. In order to evaluate the progress and impact of climate action plans, municipalities will be required to deploy multiple strategies to witness the reduction in emissions, far more than just simply setting ambitious targets [57]. Since, overlapping mandates continue to hinder policy making, cities and national governments needs policy linkage so that successful outcomes at the local level can produce a ripple effect, transcending to other regions and even international level of actions [58, 59]. More so, given the local government's connection to its citizens, cities have the ability to foster innovation, test new capacities and build capacity for the national action while generating their own, independent emission reductions [60].

2.2   Transnational Municipal Networks

Since 2000, TMNs have gained attention with the increasing number of publications focusing on their functions in transnational governance and their role in the global climate politics [52, 61]. Several definitions of TMNs have been presented lately, one of them is from Busch [62] which describes them as transnational institutions which foster participation and provides a platform for local municipalities or governments to have an exchange on topics related to the governance of climate change. This definition is however broad and does not capture the complete functionality of these networks. Kern and Bulkeley [51] proposed a more focused definition, with three main characteristics: (a) membership is voluntary, (b) networks appear to be 'non-hierarchical, horizontal and polycentric' and thus they constitute a form of

self-governance and (c) in contrast to conventional non-governmental organizations (NGOs) the networks do not exclusively focus on lobbying and mobilisation but the 'de facto' implementation of measures through the members (309 f). The emergence of the TMNs has been relatively recent and majority of these networks are established by the Global North cities i.e., cities belonging in the developed countries [63].

The popularity of TMN can be displayed through the increasing number of local municipalities joining climate action. The UNFCCC's Global Climate Action Portal has listed 10,835 actors and 247 regional actors which are engaged in total of 12161 actions at the time of writing - which is an increase from 7,025 cities in 2015 [64]. Networks arise in a different number of ways, regardless of whether it is through Mayor's arrangements, upheld by United Nations, or supported by private finances like the Clinton Foundation (supported the creation of C40) and the Rockfeller Foundation (which subsidizes the ACCCRN). These differences within the TMNs was formulated comprehensively by Castán Broto [25] as shown in Table 2-1. Broto narrowed down these differences into four broad characteristics to capture the diversity represented within the networks, namely, the scale on which the network is operating, the governance structure of the network, the types of action being undertaken and the climate action planning. For example, C40 Cities target bringing together world's megacities and most influential mayors with solid track record in climate governance and Climate Alliance focuses on collaboration with the indigenous societies against global climate change. In terms of approach towards climate policy, networks like ICLEI link climate action with the sustainable development goals (SDGs) and put more emphasis on the processes of climate governance and their carbon accounting tool, for instance, has been instrumental in the advancement of climate action strategies. On the other hand, networks such as C40 are more centered towards stitching the climate narrative as a way to progress monetary development and green economy, by providing access to financing, showcasing best practises of cities and ensuring political support for climate agenda through diplomacy. These inherent differences within the network profile and agenda certainly speaks about the characteristics of cities joining any particular network. This underlying argument was also acknowledged by Busch [58], Giest and Howlett [65] that cities with explicit attributes may bunch under one of the climate networks while not going along with others.

2.2.1 TMNs governing the climate change

To avoid any confusion, the all the overarching terms related to climate networks will be here on referred to as TMN(s). TMNs are commonly percieved as polycentric, horizontal and non-hierarchical structures. TMNs often sponsor their own resources, that is they have a head office with staff and assigned budget. TMNs aim at strategic intervention to influence the narrative of the climate change and actions focusing on its mitigation. Kern and Bulkeley [66] identified three intraorganisational governance strategies for TMNs listed as follows:

- **Information and communication:** Majority of the TMNs were established with the primary motive of sharing the knowledge and 'best' practises with the other municipalities and aiming to see 'what works' for other local governments facing the same barriers and issues. However, the authenticity, validity and replicability of these 'best' practises remains contentious due to differences in city characteristics and also, poses question on the impact, whether cities actually uptake the actions or only used as a

Table 2-1: *Different characteristics of city networks*

Scale of operation	Global Regional (e.g., European Union, North America, Asia) National	
Types of action undertaken	Membership and tailored support (e.g., ICLEI, UCLG) Networking and showcasing activities (e.g., C40) Enforcing collective commitments (e.g., Covenant of Mayors)	
Proposed climate action	Holistic approach to climate planning, through different types of climate plans Integration of climate change in ongoing local government activities-climate change mainstreaming Specific sectoral interventions (e.g., adaptation, sustainable energy, water) Collaborative approaches and partnership building	
Governance structures	Members	Mayors representing cities
		Mayors and other local leaders in their personal capacity
		Practitioners and policy-makers working in local governments
		Representatives of specific local government departments
		Specific organizations within cities, governmental or not, that play a role in climate leadership
	Management and operation and direction	Independent body with member's steering committee
		Independent body, fully autonomous
		Local governments coordination, with rotating management responsibilities among members
		Sub-section of an existing NGO

source of inspiration. Another limitation that has been highlighted in the literature is the intensity of participation within the network. The evidence suggests that cities with better resources and prior experience with climate change policies are usually in the central hubs of the network and the cities on the verge of formulating are on the periphery of the network [67].

- **Project funding and cooperation:** TMNs are observed as intermediaries connecting the local governments to the right set of actors to assist them in providing finances for the climate projects. The additional funding is targeted at enabling local climate action in the municipalities, however, the reach of this facility is limited within the network and may be utilized more often by the central members of the network.

- **Recognition, benchmarking and certification:** Showcasing cities, hosting ceremonial awards and highlighting city's efforts is one of perceived benefits in participating in the TMNs from the municipal standpoint. For example, C40 is a good example of this strategy where it hosts Mayor summits, Bloomberg Philanthropies Awards, releases best practises and provides professional certification to the municipal staff for GHG emission inventory specialist.

Besides internal governing capacity, some TMNs also engages in multi-level governance, aiming to influence the national governments and to organise the local climate work at the municipal level through intermediation and lobbying activities seeking to influence the institutions in place. Therefore, it is critical for TMNs to have sufficient governing capacity to ensure the political support remains for the implementation of plans. While these patterns in networks demonstrate a developing force of regional government contribution in worldwide climate change endeavors, what is less clear is the their impact and whether climate network membership has resulted in actual emissions reduction [36, 65, 63].

2.3   C40

C40 Cities Climate leadership group is the sole focus of the research, as prospering worldwide, representing 97 cities at the time of writing, with nearly 27% of the global economy and approximates 9,5% of people worldwide (800 million people) [31]. C40 is an organization of the world's megacities dedicated towards the climate change. C40 upholds urban areas to work together viably, share information and drive significant, quantifiable and reasonable actions on climate change. It was founded in 2005, at the initiative of then-Mayor of London, Ken Livingstone, where the Greater London Authority convened a two-day World Cities Leadership and Climate Summit. "He gathered world's largest cities, where 'large' was not a measure of size but of significance" [68]. Thus, Livingstone's vision was one of the "elite core cities", that owing to size and global relevance, can steer the climate narrative and incentivize local climate response [68]. Originally started as C20, the 20 cities that participated in the summit (large metropolitan cities such as New York, Shanghai, Sao Paulo, etc.) were the founding members of the organisation. The members agreed to climate declarations recognising cities as indispensable partners for global climate action and large cities are better positioned to formulate innovative climate solutions. Moreover, C40 endorses the IPCC findings that larger cities consumes 66% of the world's energy and are responsible for more than 3/4 of worldwide

GHG emissions [69]. C40 is making strides at handling climate change and shares the notion that city diplomacy can fill the knowledge gaps at the local level and catalyze climate action which supports the inter-governmental agreement on climate change. C40 cities enlists their goals of their network as follows [70]:

- Use knowledge-sharing and metrics-driven implementation to achieve measurable and meaningful reductions in both greenhouse gas emissions and risks associated with climate change, along with realising the local benefits of these solutions (cleaner air and water, lower energy costs, less traffic congestion, higher quality of life, longer lifespans, green jobs and green businesses.)

- Bring the world's megacities together in meaningful exchanges to speed up the global adoption of climate policies and programs that have been demonstrated to work in one or more member cities.

- Enable the world's megacities to be better prepared for climate change and to, wherever possible, minimize the risk associated with global climate change and reduce or even avoid the health, environmental and economic impacts that could result.

- Set actionable, measurable goals at the individual city level and the organisational level to ensure actions and outputs are equating to success.

The following subsections will explain the C40 sub networks grouped by membership categories and sub-network initiatives, the governance structure, followed by activities and resources within the network, and henceforth, answering the *SQ1* for this research.

2.3.1   Climate action planning in C40 cities

C40 defines climate action plan, as "A climate action plan should address the need to reduce greenhouse gas emissions, adapt to the impacts of climate change and deliver wider social, environmental, and economic benefits." The main agenda of the climate network is that, "Every signatory of the network must have developed and begun implementing a climate action plan before the end of 2020, which is consistent with the objectives of the Paris Agreement. [31]" One of the sophisticated ways, through which C40 aids cities is through the climate action planning framework (CAP framework) [71] as shown in Fig. 2-1. It help cities in aligning their climate plans with the Paris agreement and C40 provides technical assistance to cities in implementation. Although there is no specified format due to diversity of cities and their individual contexts, C40 formulated three core pillars entailing sub-categories highlighting 'essential elements' needed for transformative actions and 'go further' to strengthen the plan in current [71]. Pillar 1 focuses on the governance and coordination of the plan and the need for stakeholder and citizens engagement for development and implementation; Pillar 2 considers the evidence base and exisitng city conditions and drafts potential barriers and solutions for the actions; Pillar 3 defines the final CAP with development an prioritisation of actions and the processes of monitoring, evaluation and reporting.

To facilitate robust climate action planning, C40 in collaboration with ICLEI established a global standard for accounting and reporting city level emissions in 2011 [72]. "The Global

Figure 2-1: *C40 climate action planning framework [1]*

Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) offers a robust and clear framework that builds on existing methodologies for calculating and reporting city-wide GHG emissions" [73]. C40 has taken data-drive approach towards the climate action planning, in order to foster transparency and comparability of inventories globally. This further aids in identifying the impact of actions to create success stories and learning by other members. C40 in their flagship research publication *Climate Action in Megacities 3.0* [3] highlighted 10,000 actions are underway in C40 cities with the potential to reduce emission by 645 MtCO$_2$ by 2020.

The ambition is set but the potential of city exceed on what they are committing till now [3]. Cities face serious barriers in realizing their full potential. C40 in consultancy with Arup , formulated six challenges that cities face in delivering climate action:

- **"Vertical and horizontal coordination:** This theme concerns the relationship between a city authority and other government actors who impact city government op-

eration, duties and freedoms. It explores the interaction between different levels of government – international, national and sub-national.

- **Better internal city operations and capacity:** This theme relates to governance within the city authority, and how the city government implements its roles and responsibilities. Typically, these challenges are under the direct influence of the city leadership, and relate to structure, culture, priorities, planning, decision-making and financial practice.

- **Presenting the case for climate action:** This theme is about the challenges that cities face in collecting, accessing, analysing and presenting information about the benefits of climate action beyond simply reducing emissions or risks from climate change. These include understanding and demonstrating financial benefits as well as contributions to improved health, equity, and economic development.

- **Understanding and engaging urban stakeholders:** This theme explores how city staff, even where they have strong evidence of the benefits of climate action, may still struggle to effectively engage with and collaborate with key stakeholders, especially the community at large.

- **Collaborating with the private sector:** This theme highlights the importance and difficulty of collaboration between city government and the private sector. Private sectorf organisations are often the main delivery partner for climate action, but cities can face a range of challenges establishing an effective working relationship with the private sector and encouraging green business.

- **Finance for climate action:** This theme focuses on the challenges city governments can face in accessing funding to take climate action forward, potentially because the city government struggles to demonstrate the financial case for a climate action or to have the financial autonomy to employ appropriate fund-raising mechanisms."[33]

2.3.2 Cities and membership

C40 network offer three types of membership categories based on following criteria [74]:

- **Megacities**:

  - Population: City population of 3 million or more, and/or metropolitan area population of 10 million or more, either currently or projected for 2025.
    OR

  - GDP: One of the top 25 global cities, ranked by current GDP output, at purchasing-power parity (PPP), either currently or projected for 2025.

- **Innovator Cities**:

  - Cities that do not qualify as Megacities but have shown clear leadership in environmental and climate change work.

- An Innovator City must be internationally recognized for barrier-breaking climate work, a leader in the field of environmental sustainability, and a regionally recognized "anchor city" for the relevant metropolitan area.

- **Observer Cities**:

  - A short-term category for new cities applying to join the C40 for the first time; all cities applying for Megacity or Innovator membership will initially be admitted as Observers until they meet C40's year-one participation requirements, for up to one year.
  - A longer-term category for cities that meet Megacity or Innovator City guidelines and participation requirements but, for local regulatory or procedural reasons, are unable to approve participation as a Megacity or Innovator City expeditiously.

The main focus of the network is on megacities which is evident as only megacities are eligible to hold leadership position within the network, for instance C40 chair. Network is formed from cities in all the global regions varying from geography, technological development and institutions in place. C40 Megacities members include Sydney, Paris, Toronto. Innovator cities include Rotterdam, New Orleans, Stockholm, while Observer cities include Singapore, Shanghai, Beijing. Participation in the C40 is for nothing out of the pocket for cities, however the membership criteria of the network is not available for public access. In a personal interview with the C40 representative, it was highlighted that the main decision making body on who joins the network governed by the board of members with final decision of steering committee, who monitor city's track record and ability to contribute to C40's agenda. For example, Helsinki have been rejected in their application to join the network [Interview B.1]. The showcasing aspect of the network was of interest to the municipality but C40 wants keep the membership premium and imposes stringent membership standards. C40 has build a successful model for global collaboration, where they report that 30% of climate actions are being delivered through city-to-city collaboration and of these, 44% is through C40 facilitation [3]. Besides network membership, C40 cities can also be categorized under sub-intra-networks which focuses on specific issues and areas where the memebrs may have sufficient power and interest to take action. Hence, cities engage with other cities facing similar issues or posses similar level of interest on specific areas, such as delta cities network connecting the major delta cities of the world, Cool cities network to promote research and policy awareness to reduce urban heat island effect. Cities can also be a member of one or multiple network initiatives and can be an active or inactive member. The network initiatives are categorised into five initiatives as shown in Fig. 2-2.

"C40 Leadership Standards" formulated by the Steering committee for 2021-2024 demonstrates the efforts from the network to increase the ambition and innovation with respect to climate change action. The mandatory membership criteria enlists the following standards for cities:

- **"Plan**: City has adopted a resilient and inclusive climate action plan aligned with the 1.5C ambition of the Paris Agreement, and updates it regularly;

- **Deliver**: In 2024, city remains on track to deliver its climate action plan, contributing to increased resilience, equitable outcomes and halving C40's overall emissions by 2030;

Figure 2-2: *C40 sub-intra-networks [2]*

- **Mainstream**: City uses the necessary financial, regulatory and other tools at their disposal to address the climate crisis and mainstreams their equitable climate targets into the most impactful city decision-making processes;

- **Innovate**: City innovates and starts taking inclusive and resilient action to address emissions beyond the direct control of the city government, such as associated with goods and services consumed in their city;

- **Lead**: Mayor and the city demonstrate global climate leadership and inspire others to act in support of the Paris Agreement" [75].

2.3.3 Governance structure

C40 has a complex dynamics to fathom as it acts in the interplay of transition and innovation studies, urban studies, political science and human geography [76]. C40 has its own profile and incorporates strong vertical governance than horizontal governance in the form of multilateral cooperation with other government municipalities and external stakeholders [77]. C40 adopts multi-level climate governance model by creating synergies between government levels and also variety of stakeholders, such academia, business, non-profit and citizen groups [78]. C40 cities have actively participated in different UN initiatives and have also lobbied national governments with various climate related policies, such as green urban development [28]. The network relies heavily on steering committee which is the main decision making body, a board of directors, overseeing all the operations and day-to-day activities and the chair of C40 [79]. The steering committee is composed of C40 cities on rotational basis (currently the mayors

of Accra, Bogotá, Buenos Aires, Dhaka, Dubai, Durban, Freetown, Hong Kong, Jakarta, London, Los Angeles, Milan, Seattle, Stockholm and Tokyo) and the mayoral position is also rotational. This multilateral cooperation not only, increases the global presence and outreach of the network but also, displays the influence of translocal governance in global climate politics [80]. A notable example is the Global Protocol for regional level Greenhouse Gas Emission Inventories, partnered by CDP and ICLEI for accounting CO_2 emissions. As highlighted by Acuto [28] the critique to multilateralism, in the context of C40 is, without the coordination of the steering committee and an elected chairman who represents mayors, the already loosely connected network will probably become looser and less effective. Fig. 2-3 displays the network hierarchy within the network.
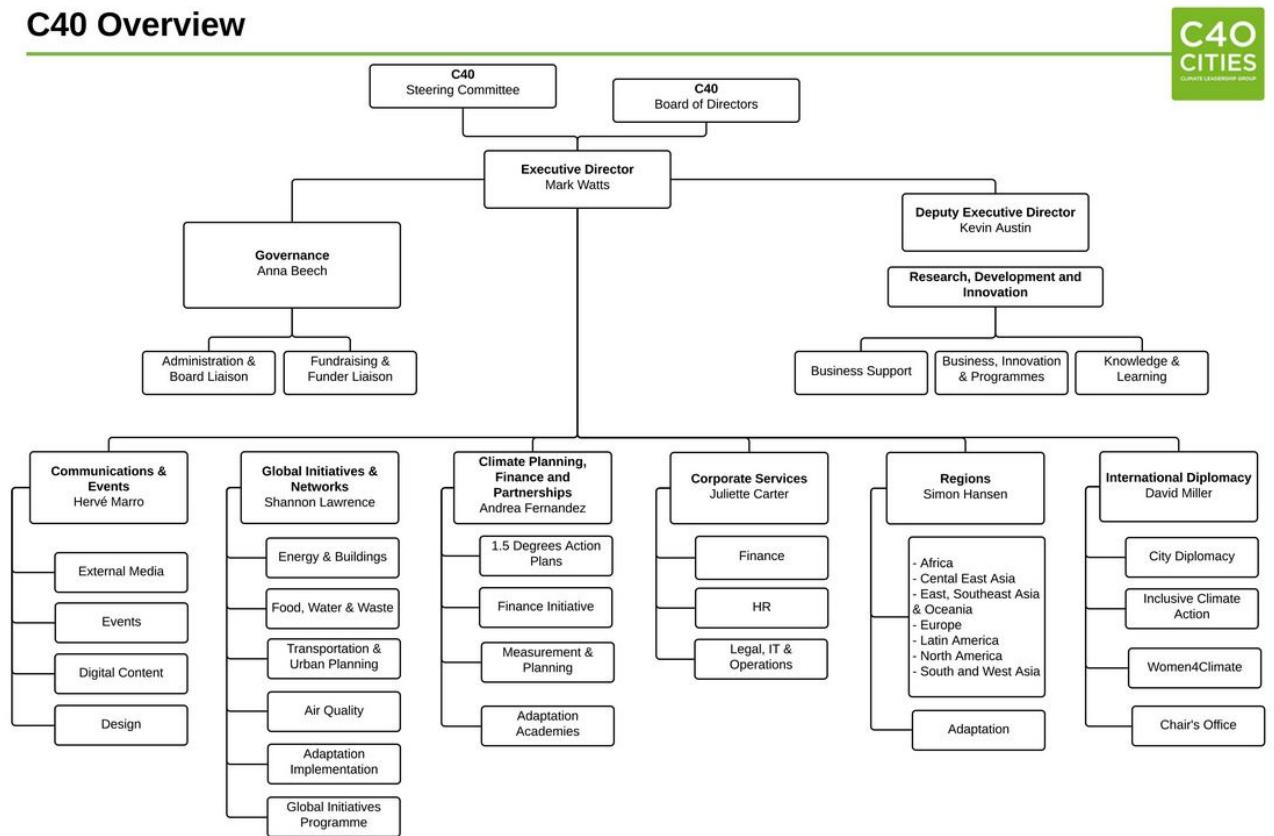
Figure 2-3: *C40 network hierarchy and representatives [2]*

According to Davidson and Gleeson [81], C40 represents a new strategic urbanism phase of transnational urban governance, as it brings together the most influential and economically-powerful mayors of global mega-cities to embrace a more noticeable political position against climate change. It is also important to acknowledge that C40 cannot be considered as a purely single entity [68]. It can be nuanced further, which is 'C40 for mayors', represented by its mayoral chair (Eric Garcetti from Los Angeles at the time of writing) and mayoral steering committee, standing as the 'voice' of (global) cities as unified entity of local governments. Yet there is other 'C40 for cities' which is mainly based in London (Head office), acting as the fundamental glue to ensure continuous engagement of the cities. Although, both are centric to urban decision making in the 'global' landscape. C40 incorporates some of the most globally

influential mayors, leading metropolitans, and is very well connected with major international businesses, philanthropic actors and other TMNs.

C40 is not to be mistaken as finite or static in nature, as the network has undergone changes in its structure and requirements since its inception. The networks like C40 are fluid and flexible with boundaries which allows them to navigate in the complex climate governance landscape of cities [68]. Cities differ in governance model and policy mechanisms to implement climate actions. It has been evident that how power is being used is more important than dimension of power at disposable by the municipality [10]. If cities lack authority, they can utilise soft governance tools couple with hard options to provide incentive for other actors to act. The latest report from C40 in collaboration with Arup [3] distinguished six governance typologies of cities in order to better understand the position of cities and what levers they use for climate action is listed as below:

- **Commanding cities:** typically use regulation and enforcement to deliver action. The role of private and other actors is often small.

- **Implementing cities:** commonly take action through the delivery of projects and programmes, often without the input of private sector and other actors

- **Providing cities:** are characterised by a high level of control over service delivery, and are able to take action through this influence.

- **Legislating cities:** achieve progress on climate change by setting policy and legislation that requires others to act.

- **Collaborating cities:** commonly act in partnership with other actors to leverage their respective powers.

- **Facilitating cities:** have limited power to take action directly, and instead focus on creating an attractive environment for others to act.

Out of all the typologies, commanding typology stood out when it comes to the implementation of city-wide plans in the respective municipality as shown in Fig. 2-4. However, they also account for the least amount of actions taken, while Collaboration typology stood out with nearly 50% of all actions delivered within this governance systems highlights the importance of coordination between stakeholders [3]. Data also demonstrates changing trend in cities towards the use of programme/project levers with a decreases in incentive/disincentive [3]. C40 argues that cities are moving away from playing less controlling part in the implementation of actions, instead engage with other external actors to drive those actions.

2.3.4   Activites and Resources

In order to fulfill the expectations from C40, alleged or not, they require serious institutional capacity to enable cities against climate change mitigation. C40 recognises that and has engage in various partnerships for external funds, organised by three alleged strategic donors ; Bloomberg, Realdania and Children's Investment Fund Foundation (CIFF), who gives the base financing to the C40 association and staff through grants. In addition, C40 partners with
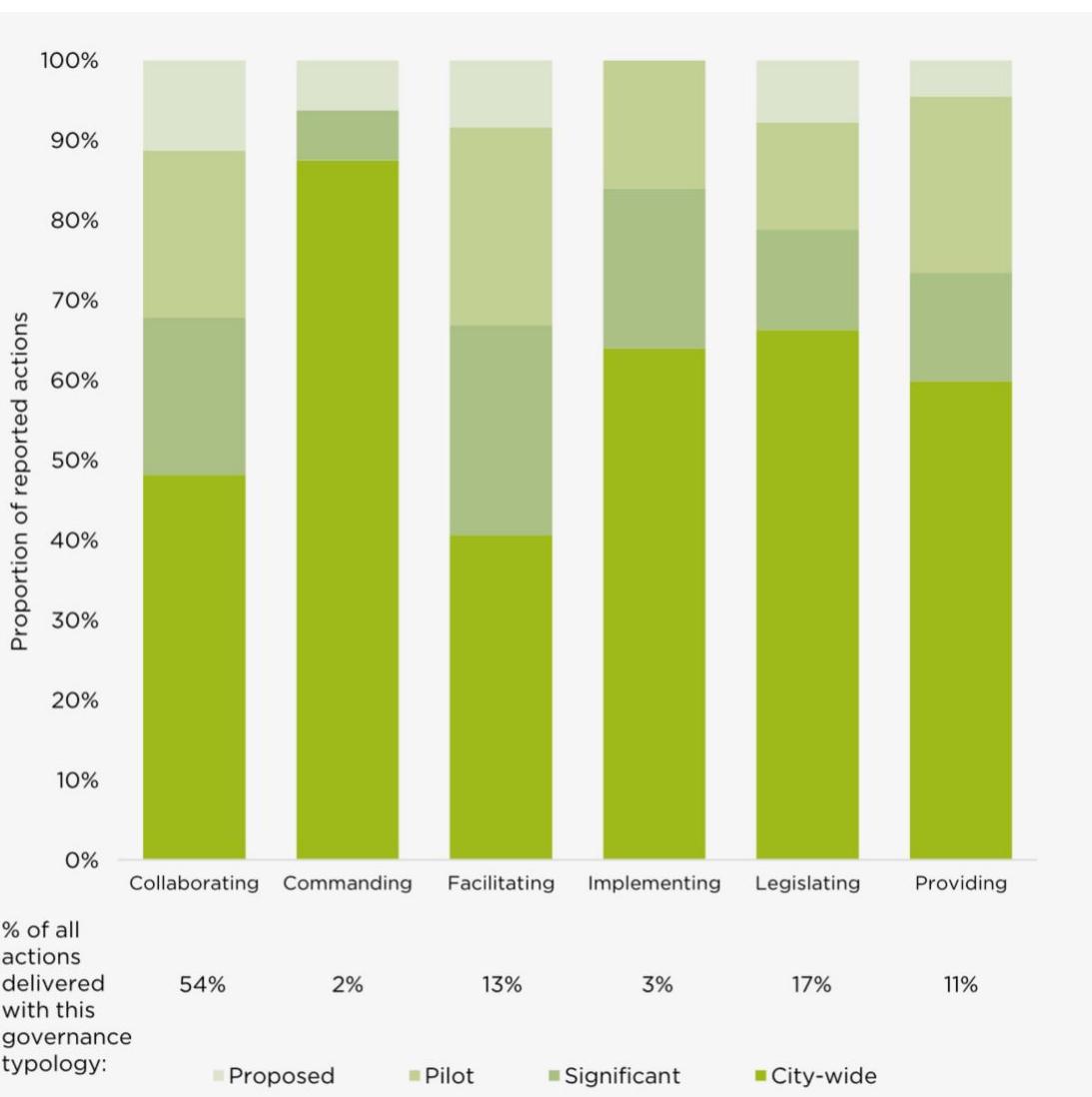
Figure 2-4: *Governance characteristics influence climate action at city-scale [3]*

other organisations that offer funding for specific initiatives or activities provided within the network. Participating cities do not pay any membership fees but provides support through allocation of resources, providing staff and often, covering travel costs, hosting events, and so on [82]. C40 network do not provide direct funding to the participating cities, but provides assistance through C40 Cities Finance Facility (CFF) which develops climate actions into bankable investments [83]. 'C40 for Cities' and more explicitly for city authorities, ordinarily characterized as C40's specialized work, is by and large less obvious and less basically examined [82]; both as far as what change, backing or impact it expects to give and by whom this is eventually given (for example C40 group, funder or conveyance accomplice).

The C40 organisation supports and manages the C40 activites, facilitates exchanges at both policy and technical level produces knowledge, communications, diplomacy and research. The practical and day-to-day mechanisms through which C40 supports and engages its mayors are

often significantly different to that of its cities. C40 for Mayors has typically consisted of a set of advocacy and diplomatic activities often manifested through strategic global platforms and events and more recently through joint declarations; all in what has been an effective attempt to raise the influence and power of cities on the global stage [68].

The main interactions within the network has been categorised by detailed evaluation done by Attström et al [82], where the most used interactions are through webinars and mail exchanges, both representing almost half of all the interactions. Other interactions include, formal and informal meetings, peer exchange, calls and workshops. The primary output of these exercises are city's participation in the organizations, expanded information and consciousness of climate change (and suggestions on the same) and a typical stage for assortment of different partners to interface and collaborate together. The C40 produces material from its exercises, through technical reports and data availability. The general consensus of the participating cities have been 'good' with the aforementioned activities and experience with C40.

2.4 Hypothesis

The climate network of C40 Cities has been successful in bringing together world's most influential cities and mayors, but much remains unknown whether signatories have accomplished any significant and measurable impacts in terms of climate mitigation or is the membership mostly symbolic. The emergence of climate networks can be characterised as the first phase of urban response against climate change [26], and it is evident that cities or local governments have the influence in global climate negotiations owing to their potential impact against negative climate externalities. The literature shows two contrasting outcome of the TMNs. Busch et al. [84] highlighted the importance of TMNs in the context of local governance through internal mobilization in Germany. Contrary to this, some authors argue the motives of cities in participating this network, as the effectiveness of climate actions remains less understood [76, 85] due to showcasing and branding motivation stronger than accelerating actions regarding climate change.

The literature on climate networks impact remains on abstract level, although several empirically based studies have come to the conclusion that climate network membership had no significant impact on local emissions or almost impossible to measure [29, 63, 61]. On the other hand, some authors have had opposite conclusions: Karhinen et al. [37] finds that Hinku climate network membership of Finnish municipalities resulted in lower emissions; Zeppel [86] concludes that Cities for Climate Protection (CCP) "played a significant role in urban climate programmes" in Australia; Hakelberg [87] highlights the fact that network membership "clearly promoted the spread of local climate strategies among European cities between 1992 and 2009"; the similar trend was validated by the study conducted by Hsu et al. [36] where they concluded that "60% of more than 1,000 EU Covenant of Mayors cities are on track to achieve their 2020 emission reduction targets"; Khan and Sovacool [88] analysis of 25 cities in the Carbon Climate Registry showed no notable difference in emissions outcomes between members that report commitments and those that did not. However, the only existing empirical study on C40 Cities Climate network membership was associated with increase in solar photovoltaic investment among 512 cities, supporting the claim of networks participation's positive influence [89]. This research acts as the basis of the hypothesis that: "*C40 network*

membership have had a positive impact on climate mitigation. "Impact" here is defined as reduction in CO2 emissions which can be traced back to any aspect of C40 Cities network membership which will be investigate in this research. The impact on CO2 emissions represents the conversion of climate mitigation strategies (increase in renewable, decarbonisation, etc.) facilitated through C40 membership and respective climate action plans.

The next chapter addresses the *SQ2: "What are the measured impacts of C40 membership on CO2 emissions?"*, building upon the hypothesis presented in this chapter. To do so, an empirical analysis will be conducted in order to gauge the difference created by the network membership of C40. The analysis aims to investigate whether C40 network cities have performed better as compared to non C40 members in the OECD countries achieved more impact Although, the analysis has its limitations which will be explained in details later on, the statistical model is an humble attempt at evaluating a climate network membership represented at global scale.

Chapter 3

Statistical Analysis

In line with answering with SQ2, this chapter constitutes the research design and results from the statistical analysis. For the analysis, a regression model is built to evaluate the impact of C40 network membership on CO_2 emissions. The chapter begins with the methods explaining selection of the GIS 1 km X 1 km annual CO_2 emissions spatial inventory from ODIAC [90] and its validation with the self-reported emissions inventory from CDP [43]. Further, the data sources and selection of control variables is explained and the selection of the model explaining the most variance in the analysis. Finally, the regression results are explained followed by the sensitivity check of the findings.

3.1 Research Design and Methodology

3.1.1 Data selection

To understand the city emission trends and have a good model for the exercise, it is important to have good data, as any model is as good as the data available. However, the city level emission datasets publicly available are not robust and present limitations for the researchers. This is mainly due to incomplete databases, different methodologies used for measuring emissions and different baseline years for cities. Hence, to overcome these limitations, the usage of GIS data has been popular in the research community which is also considered for the statistical analysis. The GIS dataset was taken from the Open-source Data Inventory for Anthropogenic CO_2 (ODIAC) which is a high-spatial-resolution global emission data product of CO_2 emissions from fossil fuel combustion [91]. Further, ODIAC data provides a resolution at 1 Km^2, ensuring its reliability for measuring city-level emissions. The GIS data is validated from a global dataset of CO_2 emissions taken from CDP and ancillary data related to emissions for 343 cities [43]. The data sets are explained in detail along with the methodology to ensure the GIS data is dependable, comparable and valid for the analysis.

CDP and Anicillary data

CDP is an open-source global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts. For cities, it provides a global platform to measure, manage and disclose their environmental data. The data is self-reported through an Online Response System provided by CDP to present one unified platform for city climate reporting, streamlining the process of reporting and ensuring simplicity and standardisation for reporting cities. The emissions disclosed to CDP are provided directly by city governments. The emissions reported by cities are an annual total per sector and scope in accordance with the GPC methodology. Background information on categorising emissions based on scope can be found in the Appendix A.1.

The global emissions data set based on CDP [92], the carbon Climate Registry of the Bonn Center for Local Climate Action and Reporting (http://carbonn.org), and a set of Chinese cities researched by Beijing University compiled with key ancillary data related to emissions prepared by [43] is selected to validate the GIS dataset. The data set entails 343 cities in nine geographic regions, and the majority of them reported emissions occurs between 2010-2015. Furthermore, total emissions (Scope 1 + Scope 2) and by scope emissions are reported in the data frame. scope emissions In addition, multiple quality checks and correction factors were integrated from individual data records by authors to ensure the robustness of the CO_2 emissions. For comparison with ODIAC data set, only OECD countries were used from this data set. The sample was reduced down to 167 cites in the OECD countries for the comparison.

ODIAC data

The Open source Data inventory for Anthropogenic CO_2 (ODIAC) is a global high spatial resolution gridded emission data product for carbon dioxide (CO_2) emissions from fossil fuel combustion [90]. ODIAC is the first of its kind global 1 km X 1 km annual fossil fuel CO_2 emissions inventory for the years 1980-2019. To reduce computation time, the inventory year from 2001-2019 as latest version 2020 was selected [91]. The data combines the worldwide point source database and satellite observations of the global nightlight distribution. The inventory was created by disaggregating the national emissions at a finer spatial scale which was achieved using the global fuel consumption statistics and emissions from power plants from a point source database. The existing ODIAC data set relies on the country level estimates made by CDIAC/ORNL which consists of CO_2 emissions from coal, oil, gas, cement production and gas flaring. ODIAC utilizes the worldwide power plant database CARMA (CARbon Monitoring and Action [93]) to gauge the nation's all-out emissions and maps them as point sources. The rest of the emissions are distributed as an aggregated area source sector using the Defence Meteorological Satellite Program (DMSP) calibrated radiance nightlight product [94]. Fig. 3-1 shows the emissions map of the ODIAC and Fig. 3-2 represents the two estimates of CO_2 emissions from fossil fuel use in Europe and North America.

3.1.2 Validation and results

This section aims at comparing the 1 X1 km gridded emission over the domain of OECD cities by comparing it with the self-reported CDP data amended by Nangini et al. [43].
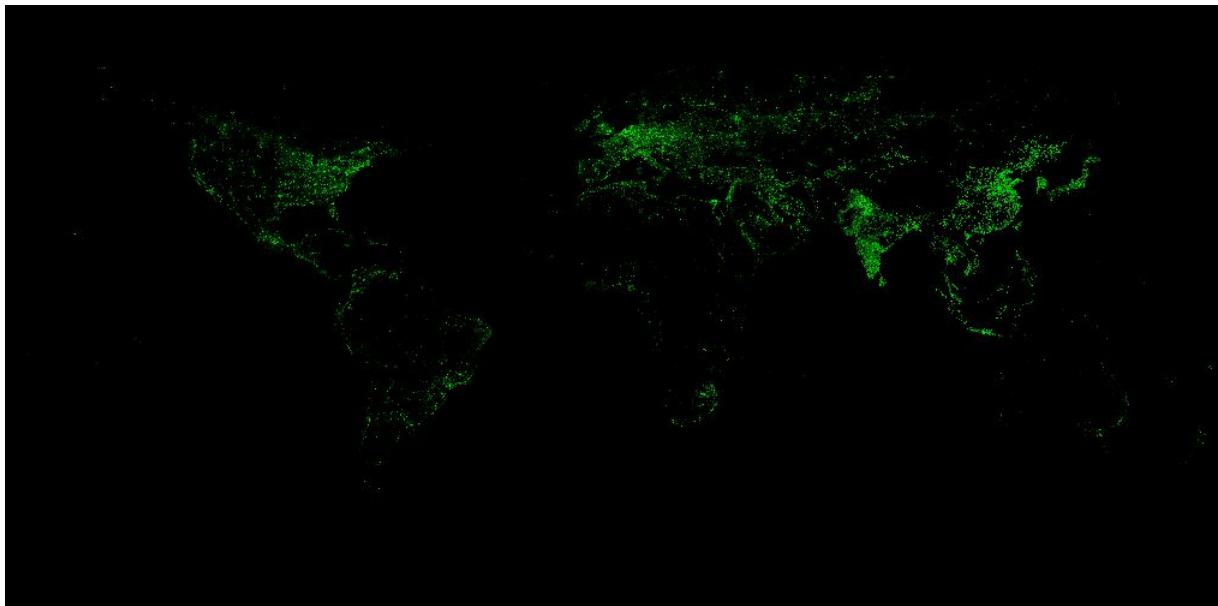
Figure 3-1: *The emissions map with the values in the unit of tonne carbon per year(tC/year)*
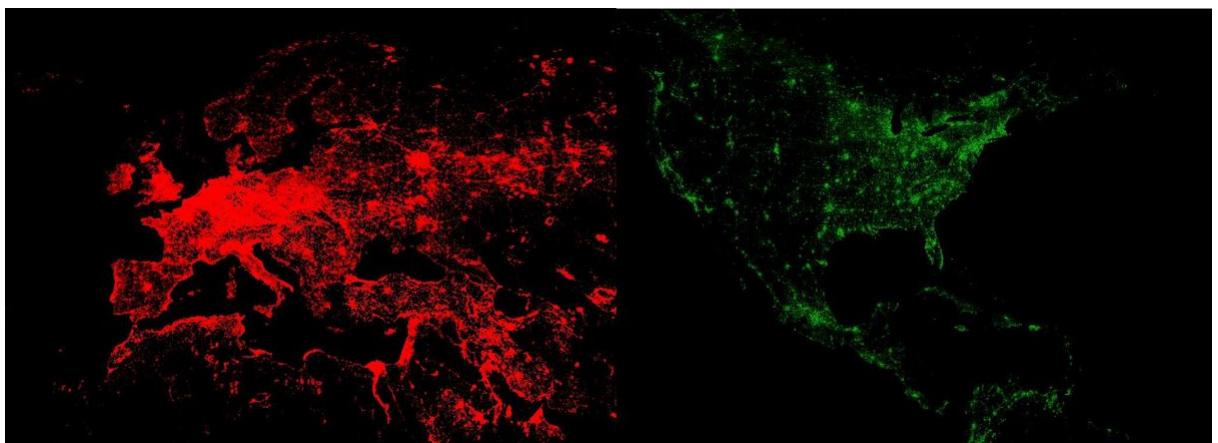
Figure 3-2: *Europe (left) and North America (right) emissions estimates over the region for the year 2019 are presented*

Tracking the progress of cities due to limited availability, consistency and comparability of data poses significant challenges in measuring the potential impact on climate mitigation. The study performed by Bansard et al.[29] on the performance of TMNs, found that out of selected 40 C40 cities, nine different base years with seven different target years were found, making an evaluation and comparison of targets and assessing the performance very difficult. Owing to the limitations such as random baseline years, variation in monitoring and reporting methodologies for cities, evaluating the impact on climate mitigation remains a challenging task [36]. Therefore, it is necessary to check and validate if the GIS data on emissions can be comparable and more so, potentially usable for the regression model.

The data extraction from the GIS database is conducted using the OECD shapefiles for

Table 3-1: *A brief summary of ODAIC and CDP.*

	ODIAC (version 2020)	**CDP**
Geographical coverage	Global	Global
Temporal coverage	2001-2019	NA
Data format	Longitudnal	Cross-sectional
Temporal resolution	Monthly	Annual
Units	tC/year	tCO$_2$-eq
Compounds of interest	CO$_2$	CO$_2$; CH4; N2O; HFCs; PFCs; SF6; NF3
Emission sectors	By fuel type	Different methodologies
Emission calculation	CDIAC approach	Various guidelines

cities in QGIS [95]. The OECD and the European Commission have jointly developed a methodology to define functional urban areas (FUAs) in a consistent way across countries [9]. The methodology obtained in defining the FUAs can be found in Appendix A.2. A definitive point of the OECD-EU way to deal with utilitarian metropolitan zones is to make an orchestrated meaning of cities and their surrounding area for global examinations as for strategy investigation related to urban development. From here on, the reference to city in the analysis is defined by the boundaries devised from the FUA methodology. The shapefiles of core FUAs is shown in Fig. 3-3. They are used to calculate the zonal statistics in QGIS to extract the aggregate emissions of each functional urban area. The monthly emission profile is further aggregated to annual profiles. The validation was conducted in R statistical language [96].

Figure 3-3: *Core shapefiles of the OECD functional urban areas*

The ODIAC data set provides a unique opportunity to evaluate the self-reported data of the cities from the bottom-up vs. top-down perspective. However, as shown in Table 3-1, there are inherent differences in the data sets which causes limitations in the direct usage of the values for the two data sets. To mitigate this, a Pearson correlation test was performed and

the correlations were plotted with ODAIC and CDP on the respective axis which can be seen in Fig. 3-4.
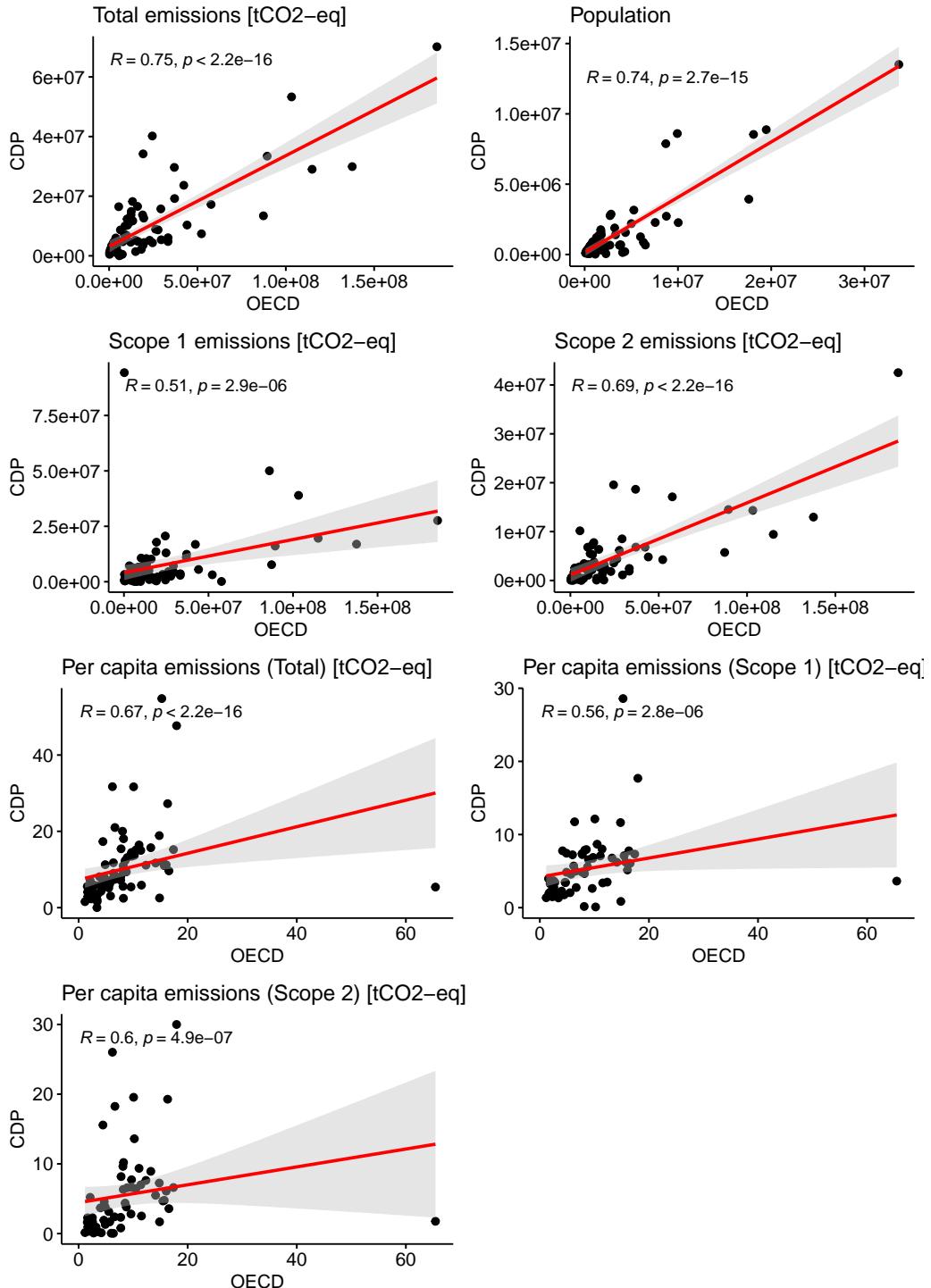
Figure 3-4: *Comparison between CDP and ODIAC data set for total emissions, population and per capita emissions*

The contrast between the data set was carefully considered and mitigated to implement the comparison in a meaningful way. Hence, *ad hoc* adjustments were made in each level of comparison. To initiate the comparison, the ODIAC data set was merged into a wide data format by matching the base year for emissions and population with city names. To standardise the city names in both the data sets, *ClimActor* [4] package was used. *ClimaActor* package streamlines the data cleaning process by providing a "key dictionary" of standard subnational actor names and contextual information. In addition, it provides a set of string matching functions (exact, phonetic and fuzzy string matching) and a set of post-cleaning functions to update and expand the "key dictionary". To mitigate the difference in units, the ODIAC emission values were converted to tCO_2 by a factor of 3.67.

A Pearson Correlation test of independence was calculated to determine if the trends in the ODIAC data set is independent of CDP. The comparison was made between the emissions in ODIAC dataset with the reported Total emissions, Scope 1 and Scope 2 emissions for the CDP data set, in order to consider the differences in emission sectors and emissions calculations. All the aforementioned variables show constant variance in their distribution. There was a strong correlation with Total emissions ($R = 0.75$, $p < 2.2e\text{-}16$) and Scope 2 emissions ($R = 0.77$, $p < 5e\text{-}13$) with the GIS emissions. First, to ensure the city boundaries used in the OECD dataset correspond roughly to the boundaries of cities used in their own declarations, the population of the two data sets is tested. The population showed strong and highly significant relation ($R = 0.89$, $p < 2.2e\text{-}16$) implying the population size is meaningfully similar in both the data. Then, both total and per capita emissions are tested with the GIS emissions. Total emissions i.e aggregation of both Scope 1 and Scope 2 emissions presented the highest correlation ($R = 0.75$, $p<2.2e\text{-}16$) with the ODIAC data. Results for per capita emissions; Total ($R = 0.67$, $p < 2.2e\text{-}16$), Scope 1 ($R = 0.56$, $p = 2.8e\text{-}06$) and Scope 2 ($R = 0.6$, $p = 4.9e\text{-}07$).

To ensure the robustness of my results, the outlier values in the data were neglected and the correlation test was performed again to confirm the findings. The test showed the same level of significance for the emissions and population, and it is unlikely that the extreme values are due to miscalculations, which also ensures the robustness of the data set. The outcomes from the test above ensure total emissions have comparable patterns with the self-reported emissions from CDP. Although, it can be argued that the d ODIAC dataset provides a unique chance to single out the impact of C40 membership on CO_2 emissions; however, the difference in the emission methodologies has not been mitigated yet, as it can be seen the differences in the absolute values is quite significant. To alleviate this, annual average % change is used for the analysis. Using the trend in emissions can be valuable for making the data more interpretable.

3.1.3 Control variables

As per the hypothesis, TMN membership results in emissions reduction in member cities. The statistical analysis is based on taking the average annual percentage change in ODIAC emissions as the dependent variable. Therefore, the variables that exogenously influences the CO_2 emissions need to be controlled to identify the impact of C40 membership on climate mitigation. The literature review was conducted as mentioned in chapter 1, to identify the potential factors and has been categorised under four main themes: i.) socioeconomic factors of the population, ii.) weather conditions, iii.) governing capacity of municipalities and iv.)

Table 3-2: Literature reviewed to finalise the co-variates

	Covariates	Adapted from	Hypothesis
Socio-economic factors	Population	Zhang et al., (2018), Zhou and Liu (2016)	+
	Population density	Liu et al., (2015), Singh and Kennedy (2015)	-
	GDP per capita	Zhang et al., (2018), Massey et al., (2014), Wei et al., (2020)	+
Weather conditions	Heating degree days (HDD)	Hao et al., (2016), Wang et al., (2010), Singh and Kennedy (2015)	+
	Cooling degree days (CDD)	Hao et al., (2016), Wang et al., (2010)	+
Governing capacity	Regional Authority Index (RAI)	Nochta and Skelcher (2020), Alkon and Wong (2020),	+ or -
	Government effectiveness	Vringer et al., (2020), Boehnke et al., (2019)	-
Regional characteristics	Urban form	Wiedenhofer et al., (2017), Ottelin et al., (2019), Minx et al., (2013)	Reference
	Country characteristics	Hsu et al., (2020), Sun et al., (2021)	Reference
	Other TMNs	Hsu et al., (2020), Kivimaa et al., (2019), Busch et al. (2015)	Reference

regional characteristics. Table 3-2 below enlists the literature among the four main themes and the variables selected for the model, including the hypothesis on the relation with the dependent variable.

Socio-economic factors

Socio-economic factors include Population, Population Density and GDP per capita. Literature clearly suggests that population has a positive relationship with city's CO_2 emissions as more populated cities differ from less populated cities in terms of energy consumption [97, 98]. In addition, population density (i.e inhabitants/km^2) is selected, as greater urban density and more compact urban forms are associated with lower emissions [99, 100]. GDP is a strong predictor for various economic activities such as resource consumption and resource availability, therefore it serves as a proxy for resources available, which can potentially influence city climate action plans and strategy [97, 101, 102].

Weather conditions

Heating degree days (HDD) and cooling degree days (CDD) capture the climatic effects acting as a proxy for weather conditions. HDD is calculated based on outside air temperature and a reference temperature (18 °C) below which heating is assumed to be required in buildings. Thus, HDD can be assumed to be a strong predictor of heating energy consumption in urban areas [103, 99]. CDD is also calculated based on outside air temperature and a reference temperature (25 °C) above which cooling is required for buildings. CDD is considered as an explanatory variable for electricity consumption since cooling is only done by electricity in urban areas [104]. Both the variables are expected to have negative relationship with emissions.

Governing capacity

The government effectiveness of a country is taken as a proxy for governing capacity due to the unavailability of data. Even though no direct relation can be observed between governing capacity and CO_2 emissions [105, 106], therefore this research provides a statistical

approach to substantiate the relationship between the two, if it exists. Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies [107]. The estimate provides the country's score on the aggregate indicator, in units of standard normal distribution, i.e. ranging from approximately -2.5 to 2.5. Another predictor acknowledged in the literature is the degree of centralisation of authority in the country, which may impact the network governance in climate-related actions [108]. The trade-offs between goals occur in environmental politics where the benefits of decentralization come into conflict with nationally optimal solutions showing mixed success with high degree decentralisation [109]. Regional authority index (RAI) is used as the predictor which is an aggregate measure of self-rule (authority exercised within the city boundaries) and shared rule (authority exercised in the country by the city or its representatives), with the scores ranging from 0-30 where relatively higher score depicts the higher degree of decentralisation [110].

Regional characteristics

The urban characteristics of a city not only impact the membership category for cities within C40, but it also affects the carbon emissions [111], however, the impacts are case-specific and related to other factors such as consumption and lifestyle choices [112]. Although, both the highest and lowest carbon footprints can be found in urban areas, carbon footprint is consistently higher in urban areas as opposed to rural settlements types [113]. Therefore, a categorical variable is added based on the classification of urban areas by OECD as large metropolitan areas if they have a population of 1.5 million or more; metropolitan areas if their population is between 500,000 and 1,5 million; medium-size urban areas if their population is between 200,000 and 500,000; and, small urban areas if their population is between 50,000 and 200,000 [114]. The local governments are committed to different number of climate networks as they aid cities in pooling resources, networking, technical capabilities, etc, [36, 115] therefore it is essential to control for other big climate networks to obtain the pure effect of C40 Cities membership as theses networks are often interlinked [58]. In addition, a dummy country was introduced to capture any time-invariant characteristics that might influence the city's emissions such as country's culture, geography [36] and different countries have different policies in the different phases of urban development to address the climate change [116].

The fossil fuel consumption is a key determinant of emissions [37], but due to the unavailability of data on industry-specific emissions in cities, it becomes difficult to control for in this study. Also, Garmann [117] showed in his empirical study that political composition also affects the CO_2 emissions as the right-wing governments are associated with emission reduction to a smaller extent than centre and left-wing governments. However, the nature of the dependent variable which is average annual percentage change won't fully incorporate the change in political composition over the years, which makes controlling for it less relevant and difficult for this research.

3.1.4 Data preparation

Data is collected from different sources entailing the CO_2 emissions which is the dependent variable and the control or independent variables as explained comprehensively in section

3.1.1 and section 3.1.3. The majority of the data handling (reading, processing, validating, visualising, compiling, saving) is performed using R [96]. Fig. 3-5 shows the datasets (D*) and their corresponding attributes used in the data preparation. Fig. 3-6 shows the sample size after merging the data sets with the original references.

The selection methodology of sample size is non-probabilistic and can be interpreted as purposive sampling [118], although, despite the concern of potential bias in the sample, the selection of OECD countries provided a harmonious way of using and analysing the GIS data set for the research, therefore the selection more or less make amends for the bias as the majority of the participation in TMNs is observed in Western countries [119]. The emissions data extracted from the ODIAC using the Functional Urban Areas (FUA) by OECD enlisted 1,168 cities. The majority of data for covariates is pooled from OECD.stat covering from 2001-2018 [120]. The socio-economic indicators and weather conditions for 668 cities or FUAs representing 30 OECD countries is available. Each FUA in the sample has a designated FUA code and the cities with a 'no match' were dropped from the data set. It was made sure that none of the Large metropolitan areas, medium-size urban areas and C40 members was dropped from the sample. The data for Regional Authority Index data for 81 countries are combined along with the Government effectiveness indicator for all the OECD countries from World Bank [121]. Lastly, to control for the other TMNs, the data was harnessed from *ClimaActor* package [4] which is the largest harmonized global dataset of cities and regional governments participating in the climate networks.
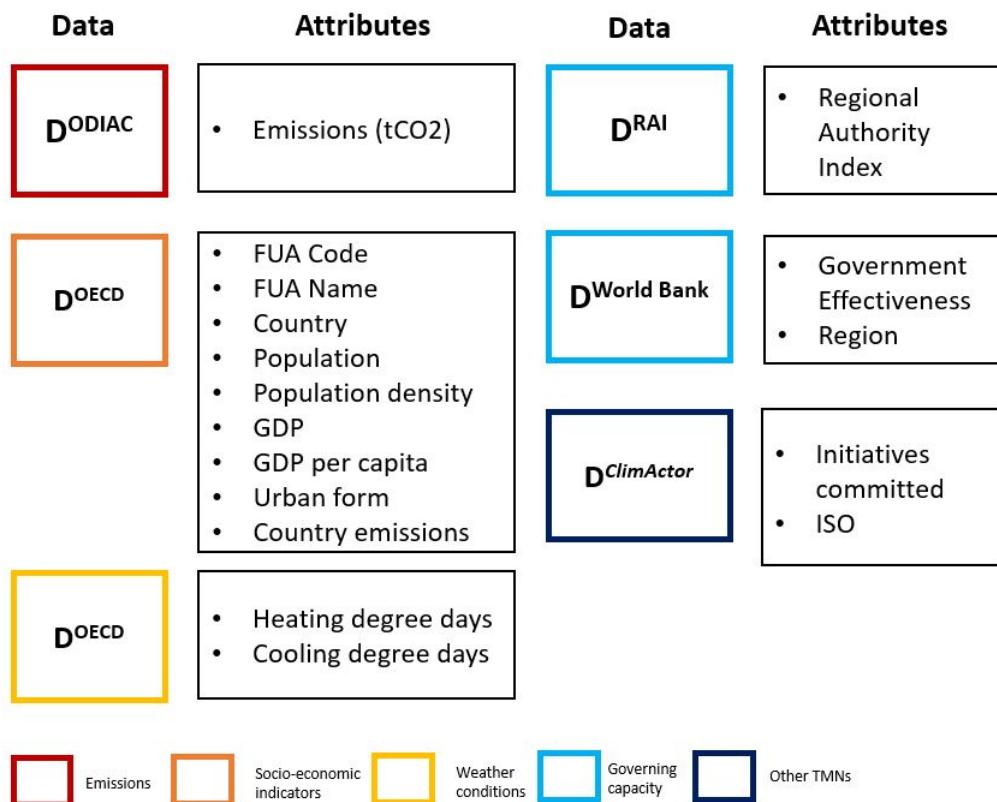
Figure 3-5: *Source data set and their attributes*
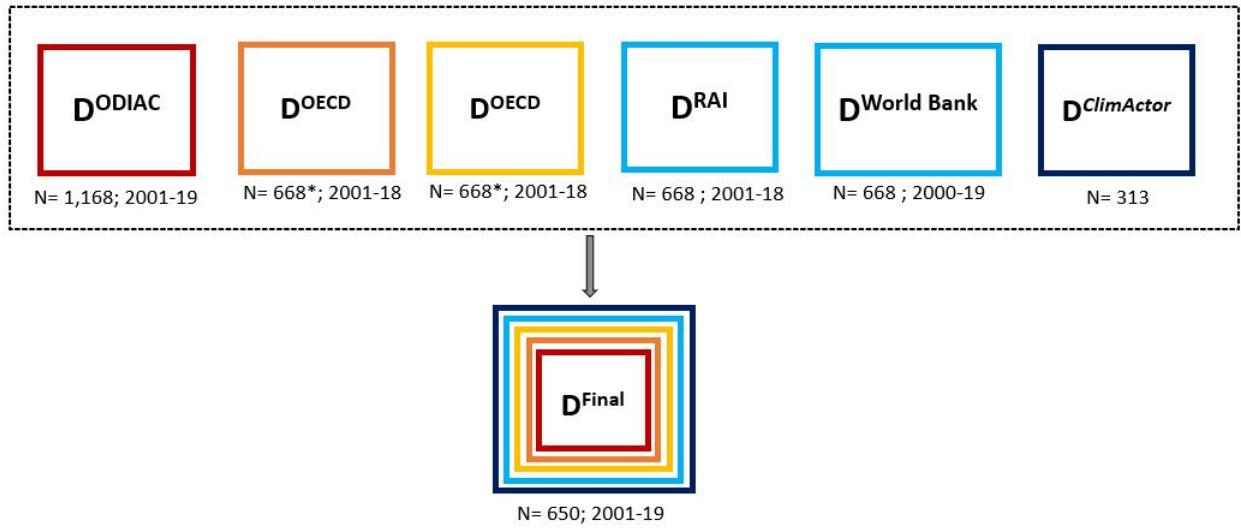
Figure 3-6: *Number represents cities and temporal coverage respectively. '*' represents some missing values for the attributes*

The final sample lists 650 cities representing 30 OECD countries. The cities are spread across four different regions based on the World Bank's classification of countries: 12.9% from East Asia & Pacific, 46.3% from Europe & Central Asia, 13.1% from Latina America Caribbean and 27.7% from North America. Due to the unavailability of data on joining year of C40 cities, the panel data is converted to cross-sectional data due to no relation of C40 membership with time, where all the variables besides Regional Authority Index (no relation with time) and weather conditions variable (only average values are taken as the percentage annual change is quite small) are converted into average annual percentage changes for their respective temporal coverage. Table 3-3 lists the climate networks belonging to the cities in the data set, along with the rationale for inclusion or exclusion in the study. It is evident that majority of the climate networks belong to Europe and North America. Figure 3-9 represents the number of cities participating in selected climate networks from their respective region.

Final sample and descriptive statistics

The sample is composed of 650 cities spanning over 30 OECD countries with a total population ranging from 49,775 (Wetzlar, Germany) to 33.7 million (Tokyo, Japan) in 2015. Colombia recorded the highest percentage increase i.e 3.2% while Denmark was the most successful in reducing their emissions by an average of -2.4% from 2001 to 2019. Looking at the governance indicators, Denmark stood out in terms of absolute values for government effectiveness (2.5) while Colombia had the worse score for the same (-0.4). Although, the trend in government effectiveness stood out for Mexico which improved the most (19.3 %) for the coverage period, while Colombia performance degraded by almost 40%. German local governments stood out as the country ranked highest in terms of decentralisation in the data, and on the other end, cities in Latvia do not have the same role as they rank lowest in the index. At the city level, Milton Keynes, UK witnessed the lowest percentage reduction for both total (-4.68%) and per capita emissions (-5.65%) while Edmonton, Canada had the highest increase for both total

Table 3-3: TMNs represented in the final data and the rationale for inclusion in the analysis

Transnational Municipal Network	Founding Year	Incl./Excl.	Rationale
C40	2005	Included	Focus of the research
Carbonn	2010	Exluded	Reporting platform; does not actively engage in emissions reduction
CDP Cities	2000	Excluded	Reporting platform; does not actively engage in emissions reduction
Climate Alliance	1990	Included	Cities embrace voluntary commitment to reduction CO_2 emissions by 10% every 5 years
Climate Mayors	2014	Included	Cities are committed to emission reductions and upholding the Paris Agreement through climate action and policy
EU Covenant of Mayors	2008	Included	Signatory cities pledge to EU 40% emission reduction target by 2030
Global Covenant of Mayors	2016	Included	Cities are committed towards dedicated climate mitigation and adaptation plans and strategy
ICLEI	1990	Included	Cities have undertaken voluntary targets to reduce emissions
Japan Zero Carbon Cities	2020	Excluded	A recent initiative to have any influence on the CO_2 emissions
NAZCA	2014	Excluded	An online portal hosted by UNFCC which highlights actions taken by signatories against climate change
Race to Zero	2021	Excluded	Campaign rallying all the actors for zero carbon emissions by 2050; new initiative to have any impact on emissions
Under2 Coalition	2015	Included	Cities committed again net zero carbon target by 2050
We are still in	2017	Included	Campaign supporting organizations to push for new and ambitious climate actions but no commitment towards defined emissions reductions

Figure 3-7: *Cities committed in TMNs based on ClimActor package [4]*

(-5.65%) and per capita emissions (5.7%). Table 3-4 shows the descriptive statistics for the continuous variables in the dataset.

Within the sample, 41 C40 cities are covered out of 97 members with a population ranging from 158,700 (Heidelberg, Germany) to 33.7 million (Tokyo, Japan) and representing international economy's (million USD) from 22,051 (Venice, Italy) to 1,746,596 (Tokyo, Japan) in 2015. Within the C40 members, London, UK recorded the highest reduction in total emissions averaging -2.6% while Vancouver, Canada had the highest increase in emissions accounting for 6%. The trend is similar for per capita emissions as well, where both London and Vancouver had the highest (4.5%) and lowest (-3.65%) change in the emissions. The percentage change in economic activities in the municipalities is captured by GDP per capita, where Rome, Italy experienced the highest decrease accounting for -0.63% and Warsaw, Poland experienced the highest increase for 5.86%. Fig. 3-8 and Fig. 3-9 shows the distribution of data for both C40 and non-C40 cities.

In the dataset, Medium size urban areas (population from 500,000 to 1,5 million) are represented the most, accounting for 220 cities. Fig. 3-10 shows the composition of different categories of cities committed to different climate networks. The most signatories are found in

Table 3-4: Descriptive statistics of continuous variable

Statistic	N	Mean	St. Dev.	Min	Max
Emissions change, total (tCO_2)	650	0.38%	1.71	−4.68%	7.82%
Emissions change, per capita (tCO_2)	620	−0.47%	1.60	−5.65%	5.70%
Population trend (number of inhabitants)	620	0.76%	0.89	−1.60%	5.62%
Population density trend (inhabitants/km2)	650	0.75%	0.88	−1.59%	5.61%
GDP (Million USD)	479	1.88%	1.20	−0.72%	7.30%
GDP per capita ($)	479	1.16%	1.02	−1.17%	5.87%
Government Effectiveness	650	0.40%	9.54	−39.60%	19.30%
Avg. Annual Heating Degree Days	646	2,126.49	1,135.90	0.00	5,271.33
Avg. Annual Cooling Degree Days	646	216.65	370.23	0.00	2,228.67
Country Emissions (tCO_2)	650	−0.33%	1.30	−2.41%	3.16%
Regional Authority Index	650	22.81	8.71	0	35

the Global Covenant of Mayors, and within C40 cities, 31 cities belong to the large metropolitan areas out of total of 49 cities in the dataset, which was expected since it's the climate network of the largest global cities. The global distribution of C40 cities can be found in the Appendix A.2 and the list of different urban areas in OECD countries is entailed in Appendix A.3. Table 3-5 shows the descriptive statistics based on the OECD specification of city urban area.

3.1.5 Regression modelling

A regression analysis has been performed to test whether C40 membership translated into a decrease in CO_2 emissions through controlling for the range of variables described in section 3.1.3. For the empirical testing: a multiple linear regression model for each city was used to assess the differences in impacts of each determinant. Equation 3-1 shows the empirical model used for the analysis, where

$$i \in \{1, \cdots, 650\}$$

are cities in the dataset. $E_{i,c}$ is the average annual percentage change in CO_2 emissions from 2001-2019 for city i. α_i are the municipality-specific fixed effects or the y-intercept, x_i includes the control variables and the error term ϵ_i which is independent and identically distributed over the cities i. The point of interest for this research is the coefficient of C40 dummy indicator β_0, which can directly be interpreted as the percentage change in emissions due to C40 membership. The C40 variable was formulated as shown in equation 3-2. λ_i is the country dummy to capture unseen, time-invariant elements normal to cities within a country c. γ_i is the city urban area dummy based on OECD classification [114] and δ_i dummy is added to control for differences of effects from different climate networks.

$$E_{i,c} = \alpha_i + C40_i\beta_0 + x_i\beta + \lambda_c + \gamma_i + \delta_i + \varepsilon_i \qquad (3\text{-}1)$$

Table 3-5: Descriptive statistics of city urban area

Statistic	N	Mean	St. Dev.	Min	Max
Large Metropolitan Areas					
Emissions change, total (tCO_2)	49	0.33	1.85	-2.62	6.06
Emissions change, per capita (tCO_2)	49	-0.49	1.79	-3.65	4.50
Population trend (number of inhabitants)	49	0.84	0.66	-0.52	2.11
Population density trend (inhabitants/km2)	49	0.84	0.66	-0.51	2.12
GDP (Million USD)	47	2.04	1.02	0.15	4.98
GDP per capita ($)	47	1.14	0.78	-0.64	3.63
Government Effectiveness	49	-3.60	10.92	-39.60	2.75
Avg. Annual Heating Degree Days	49	2,088.02	1,120.69	0.00	4,319.50
Avg. Annual Cooling Degree Days	49	235.89	409.85	0.00	2,228.67
Country Emissions (tCO_2)	49	-0.37	1.28	-2.34	3.16
Regional Authority Index	49	23.76	8.39	6	35
Medium Size Urban Areas					
Emissions change, total (tCO_2)	220	-0.05	1.53	-4.18	4.42
Emissions change, per capita (tCO_2)	220	-0.63	1.65	-5.65	4.17
Population trend (number of inhabitants)	220	0.60	0.75	-1.60	2.95
Population density trend (inhabitants/km2)	220	0.60	0.75	-1.59	2.95
GDP (Million USD)	177	1.72	0.97	-0.72	5.95
GDP per capita ($)	177	1.04	0.83	-0.93	5.44
Government Effectiveness	220	-2.63	9.39	-39.60	4.53
Avg. Annual Heating Degree Days	220	2,224.99	1,054.30	0.00	5,001.83
Avg. Annual Cooling Degree Days	220	196.91	321.78	0.00	1,999.44
Country Emissions (tCO_2)	220	-0.58	1.15	-2.41	3.16
Regional Authority Index	220	24.31	8.46	4	35
Metropolitan Areas					
Emissions change, total (tCO_2)	117	0.24	1.45	-2.34	7.82
Emissions change, per capita (tCO_2)	117	-0.42	1.57	-3.39	5.70
Population trend (number of inhabitants)	117	0.69	0.82	-0.74	3.08
Population density trend (inhabitants/km2)	117	0.69	0.82	-0.74	3.09
GDP (Million USD)	108	1.87	1.20	-0.42	5.48
GDP per capita ($)	108	1.07	0.99	-0.99	5.39
Government Effectiveness	117	-1.37	7.37	-39.60	5.08
Avg. Annual Heating Degree Days	116	2,167.73	1,121.25	0.00	5,197.56
Avg. Annual Cooling Degree Days	116	236.56	334.37	0.00	2,088.39
Country Emissions (tCO_2)	117	-0.56	0.94	-2.34	3.16
Regional Authority Index	117	24.36	8.61	0.00	35.48
Small Urban Areas					
Emissions change, total (tCO_2)	124	0.12	1.53	-4.02	4.76
Emissions change, per capita (tCO_2)	124	-0.54	1.68	-5.02	5.33
Population trend (number of inhabitants)	124	0.67	0.82	-0.95	4.56
Population density trend (inhabitants/km2)	124	0.67	0.83	-0.95	4.65
GDP (Million USD)	115	1.51	0.99	-0.02	5.92
GDP per capita ($)	115	0.96	0.77	-0.77	3.27
Government Effectiveness	124	-0.86	3.59	-39.60	2.75
Avg. Annual Heating Degree Days	122	2,588.84	946.27	60.89	5,271.33
Avg. Annual Cooling Degree Days	122	87.05	196.12	0.00	1,261.22
Country Emissions (tCO_2)	124	-0.96	0.75	-2.41	3.16
Regional Authority Index	124	25.51	9.20	0	35
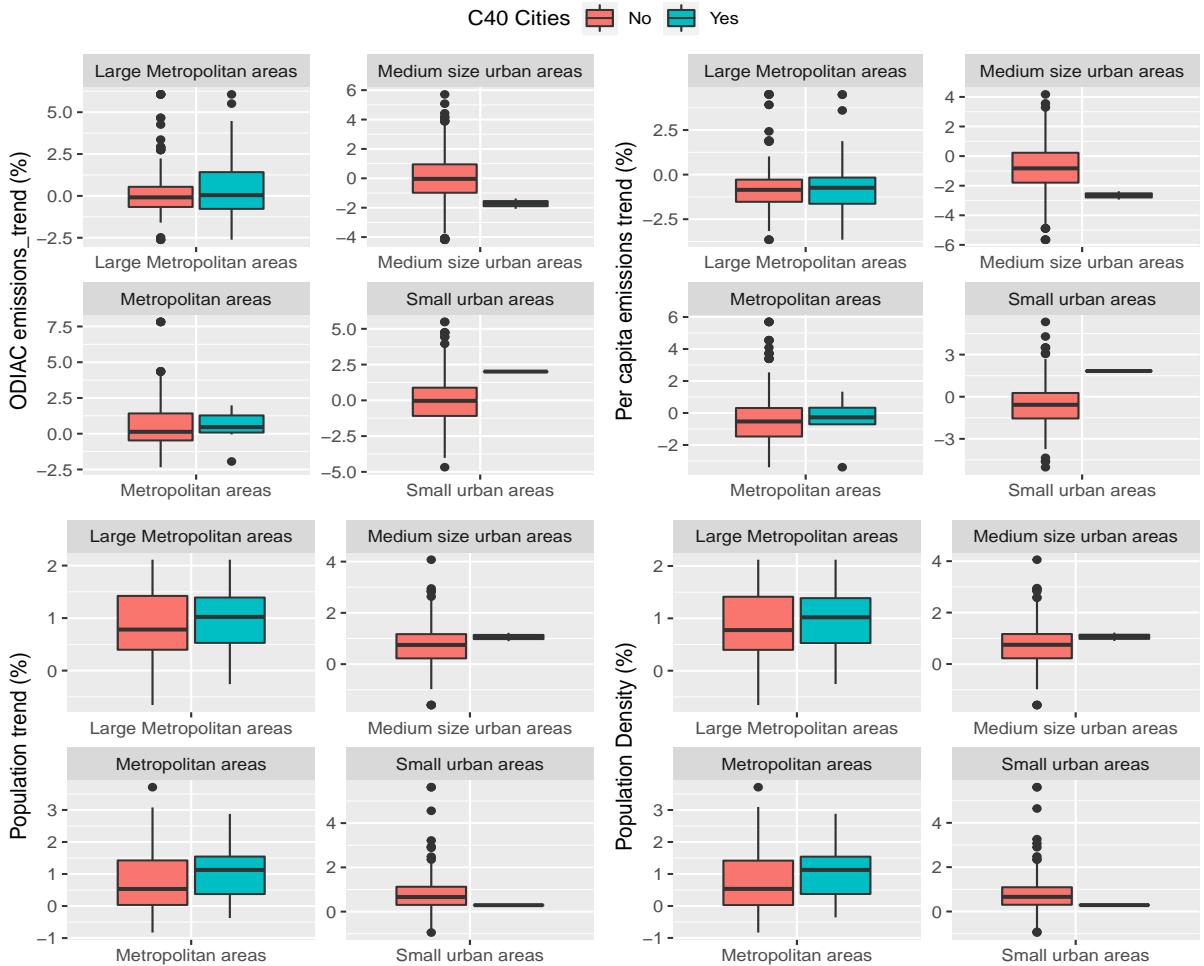
Figure 3-8: *Comparing variables in different functional urban areas for both C40 and non members*

$$\text{C40 }_i = \begin{cases} 1 = & \text{city } i \text{ belongs to the C40 network} \\ 0 = & \text{city } i \text{ does not belong to the C40 network} \end{cases} \qquad (3\text{-}2)$$

Model structure and candidate variables

For the hypothesis testing, multiple linear regression (MLR) is used by preparing seven models as listed below:

- **Model 1:** controlling for National emissions

- **Model 2:** controlling for National emissionss + socio-economic indicators

- **Model 3:** controlling for National emissionss + socio economic indicators + Weather conditions
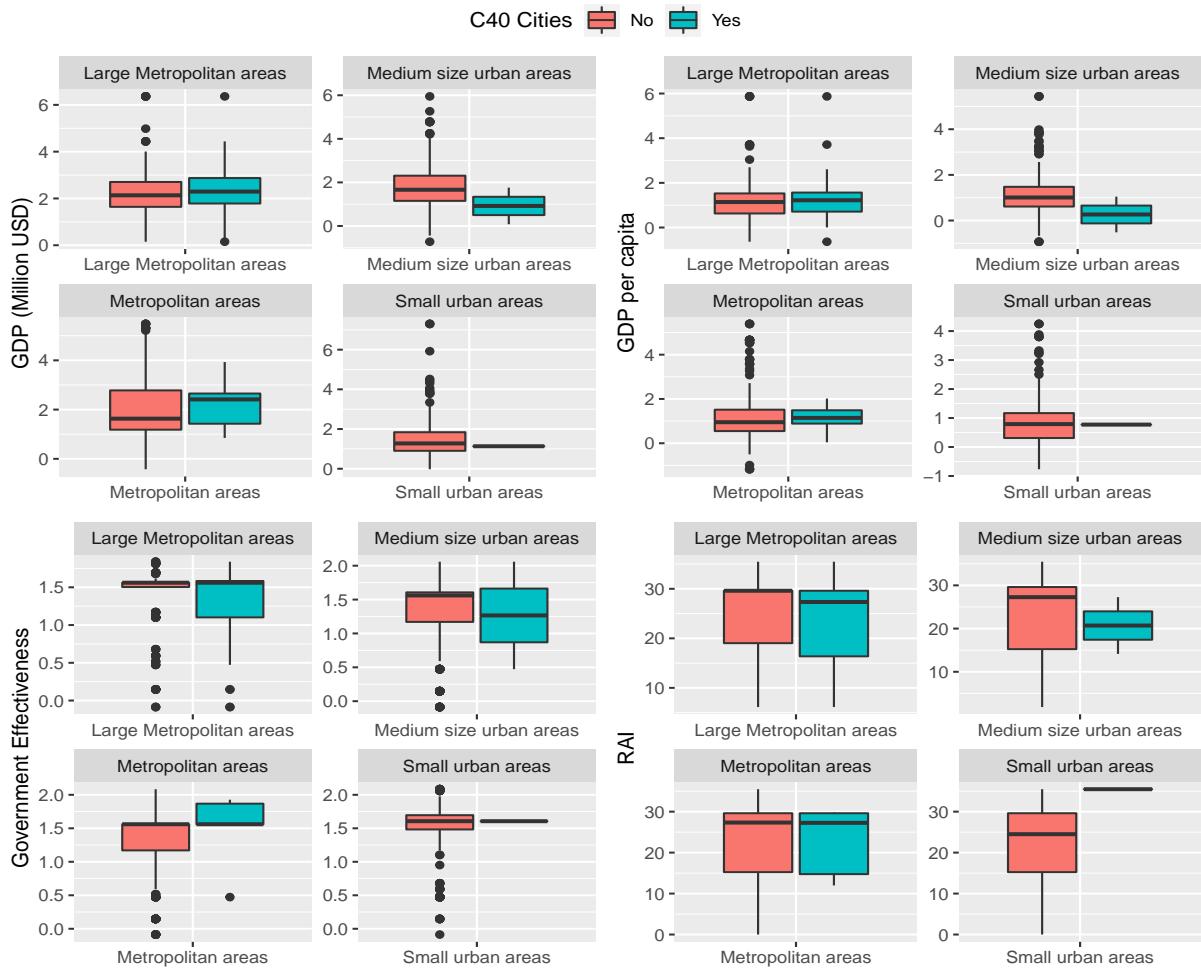
Figure 3-9: *Comparing variablesin different functional urban areas for both C40 and non members*

- **Model 4:** controlling for National emissionss + socio economic indicators + Weather conditions + Governing capacity

- **Model 5:** controlling for National emissionss +socio economic indicators + Weather conditions + Governing capacity + Other initiatives

- **Model 6:** controlling for National emissionss + socio economic indicators + Weather conditions + Governing capacity + Other initiatives + City dummy

- **Model 7:** controlling for National emissionss + socio economic indicators + Weather conditions + Governing capacity + Other initiatives + City dummy + Country

The models are prepared using the stepwise automatic search method, where the variables with the highest correlation with the dependent variable are the first to enter the model, and once all the predictors are in the model, the test is performed to check which predictors are significant [122]. Variables with high correlation with other predictors are excluded from the

Figure 3-10: *City mix*

analysis such as % change in population density which has not been used in the analysis as it's perfectly collinear with the % change in population as shown in Fig. 3-12 and the same for GDP and GDP per capita with a correlation of 0.78. For the regression analysis, the data should follow a normal distribution for the regression assumptions to be satisfied as shown in Fig. 3-11. To find the best-fit line for each independent variable, multiple linear regression calculates three things:

- The regression coefficients that lead to the smallest overall model error (residuals).

- The t-statistic of the overall model. For large samples: $|t| > 1.96$ implies coefficient is statistically significant at 5% level.

- The associated p-value (how likely it is that the t-statistic would have occurred by chance if the null hypothesis of no relationship between the independent and dependent variables was true).

It then calculates the t-statistic and p-value for each regression coefficient in the model
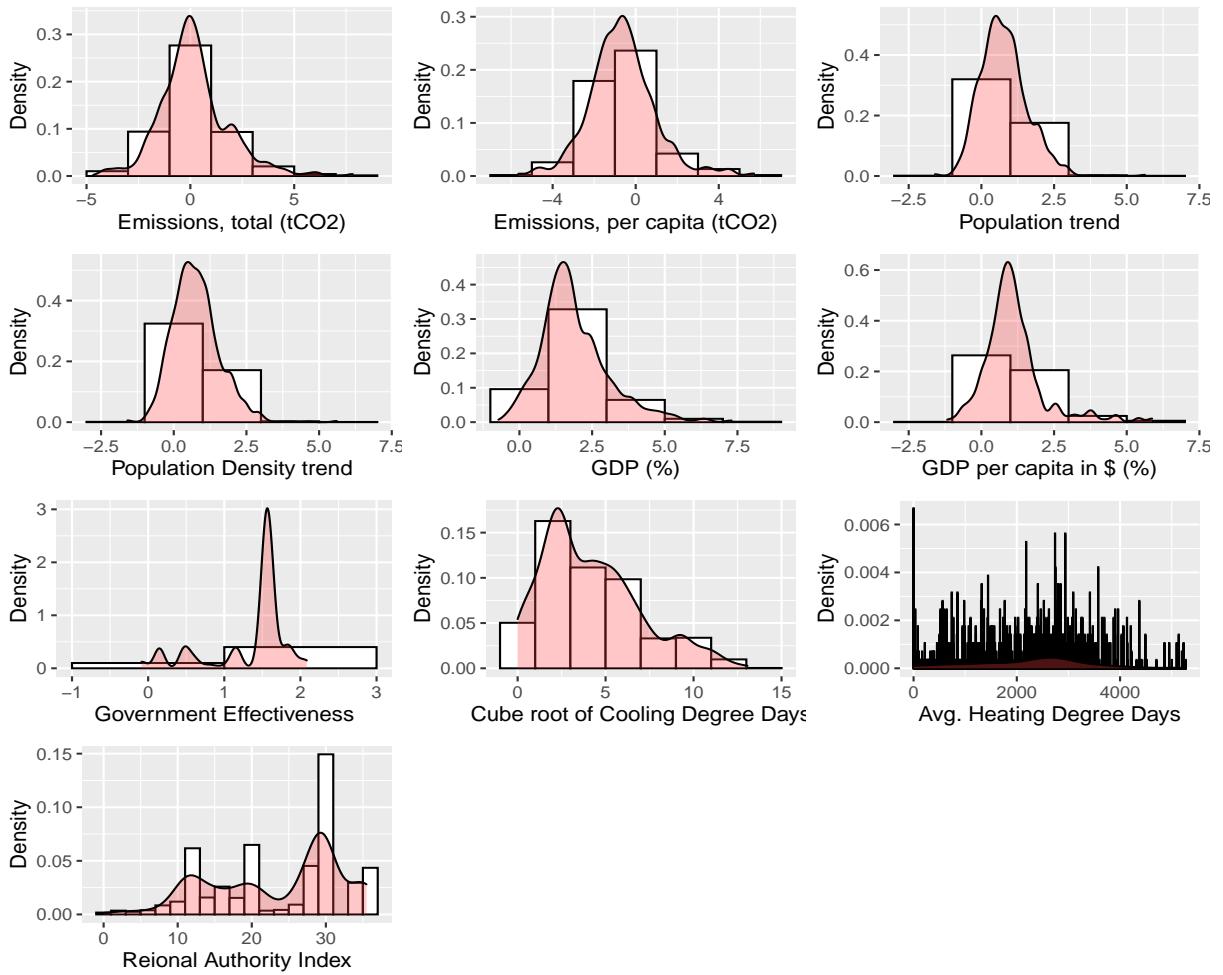
Figure 3-11: *Distribution of variables in the analysis*

The decision criteria for model selection is to strive for the parsimonious models (model with highest explained variance with lease number of predictors) [123]. The parsimony approach avoids 'overfitting' of the model and fewer predictors leads to higher generalizability of the results due to lack of idiosyncrasies of the sample. Multiple ordinary least square (OLS) regression is used to assess which of the multiple predictors are more or less important in predicting outcome variables or how one or more predictors relate to the outcome when controlling for some variables known to correlate with the outcome variable [124].

3.2 Results

The statistical results showed no significant relation of C40 membership on the CO_2 emissions in any of the models with an estimate of 0.01 and 95% confidence interval between -0.33 & 0.36 in *Model 7* (Table 3-6 & Table A-3). The selection of the model is based on R^2, and the adjusted R^2, which is the measure of the model's quality. Mathematically, it is the fraction of the variance of the dependent variable that is explained by the regression model. The
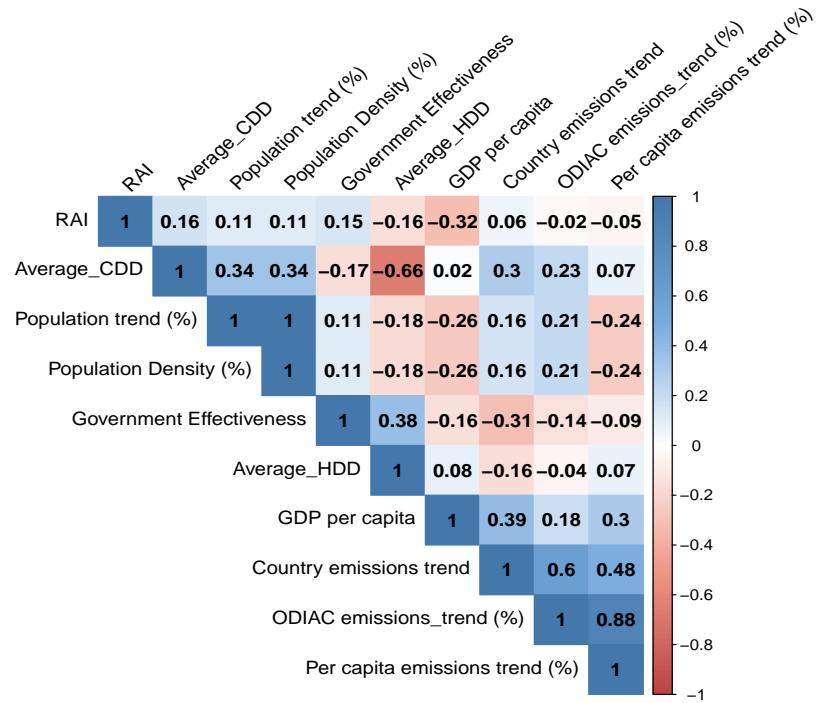
Figure 3-12: *Correlation Matrix*

remaining variance may not be explained due to exogenous factors such as unknown variables or sampling variability. Although adjusted R^2 is a better decision criterion for the selection of model as it takes into account the number of variables in the model and is a more realistic assessment of its effectiveness. The explanatory power of *Model 1* was relatively low with adjusted R^2 of 0.44. Model 7 is the most detailed with all the control variables defined in section 3.1.3 with adjusted R^2 value of 0.55. In this case, *Model 7* explains 55% (0.55) of the variance in the emissions and the rest is unexplained. The highest increase in the explanatory power was achieved when the country dummy was included.

Alongside the relationship between the C40 membership and CO_2 emissions, the analysis provides other meaningful and intriguing results based on the complete model. The analysis showed that cities with higher emissions are associated with countries where a % increase in national emissions trend accounts for a 1.74% increase in the cities. As expected, the annual percentage change in population has a positive significant impact on the annual percentage change in CO_2 emissions where a % increase leads to 0.21% higher emissions annually. Although, it was found that % annual change in GDP per capita, was significant until the country characteristics were included in the analysis. For the weather conditions, the results

are counterintuitive as the average annual heating degree day had no significance while an additional unit of cooling degree day accounts for a 0.1% increase in the annual CO_2 emissions. Interestingly, the government effectiveness showed a -2.2% lower annual impact on the CO_2 emissions with a % increase in the governing capacity, accounting for a potential 20% reduction in emissions for a decade. This result has important implications for both national and local policy makers to ensure better preconditions for governing capacity, for instance, better financing for the municipalities. In addition, regional governments with a high degree of authority over their territory are associated with higher emission reduction representing an annual decrease of 0.12%. The degree of decentralisation in the OECD countries has contributed almost 2.3% reduction in CO_2 emissions over the temporal coverage which is not a huge impact but still a modest improvement.

The highest gain in the explanatory power was explained by grouping cities under respective countries, with a trend in GDP per capita and annual average HDD losing their significance. It can be inferred that country-level effects are significant and the aforementioned indicators are not crucial for explaining emissions with the country-level fixed effects. Based on the results, none of the climate networks except ICLEI had any significant impact on the CO_2 emissions, although this finding is susceptible to bias as the sample size in the ICLEI Cities for Climate Protection climate network is not large enough to generalise the findings. Based on the results, the small urban areas have been associated with an increase in emissions trend relative to both large metropolitan areas ($\approx 3\%$) and medium-size urban areas ($\approx 4\%$).

3.2.1 Sensitivity Analysis

Sensitivity analysis involves a series of methods to quantify how the uncertainty in the output of a model is related to the uncertainty in its inputs. In other words, sensitivity analysis assesses how "sensitive" the model is to fluctuations in the parameters and data on which it is built. The implications of sensitivity analysis can be important in identifying errors in the model itself and exploring more broadly the relationship between the inputs and outputs of the model. To perform the sensitivity analysis, two common techniques have been used: (a) to allow variation in the functional forms of the variables in the dataset and (b) conduct sub-group analysis to substantiate the findings further [125]. The C40 membership showed no significance in any of the checks performed with the change in the functional form of variables, which is explained and listed in Appendix A.4. Moreover, the analysis was check between global north and global south cities and no relationship was found in either A-6. Even with no covariates, C40 membership was not statistically significant. The sub-group analysis will be discussed in this section which is primarily classified based upon regions, city urban area and time-based grouping using the *Model 7* configuration.

Analysis for the regions

The C40 membership estimate was found to be statistically insignificant in all four regions. All the four regional classifications have positive relationships with their respective national emissions % change, although the impact appears to be bigger for North American (NA) cities where a % increase in the national emissions is associated with a 4.05% increase in emissions at the city level. Table 3-8 shows the results for all of the four regions. For population, all

Table 3-6: Regression results

	Dependent variable:		
	Emissions change (%), total (tCO2)		
	Model1	**Model2**	**Model3**
C40	0.10	0.05	0.12
	(0.20)	(0.20)	(0.19)
National emissions	0.96***	0.95***	0.96***
	(0.03)	(0.04)	(0.04)
Population trend (number of inhabitants)		0.23***	0.20***
		(0.05)	(0.06)
GDP per capita ($)		−0.03	−0.07
		(0.04)	(0.04)
Avg. Annual Heating Degree Days			0.0002***
			(0.0000)
Avg. Annual Cooling Degree Days			0.001***
			(0.0002)
Constant	0.67***	0.53***	−0.04
	(0.04)	(0.09)	(0.15)
R^2	0.44	0.37	0.39
Adjusted R^2	0.44	0.37	0.39

Note: *p<0.1; **p<0.05; ***p<0.01

Table 3-7: Regression results-contd

	Dependent variable:			
	Emissions change (%), total (tCO2)			
	Model4	**Model5**	**Model6**	**Model7**
C40	0.10	0.05	0.10	0.01
	(0.19)	(0.20)	(0.20)	(0.18)
National emissions	0.99***	1.02***	1.02***	1.74***
	(0.05)	(0.05)	(0.05)	(0.17)
Population trend (number of inhabitants)	0.19***	0.20***	0.20***	0.21***
	(0.06)	(0.06)	(0.06)	(0.06)
GDP per capita ($)	−0.12***	−0.11**	−0.09**	−0.06
	(0.04)	(0.04)	(0.04)	(0.05)
Avg. Annual Heating Degree Days	0.0002***	0.0002***	0.0002***	−0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0001)
Avg. Annual Cooling Degree Days	0.001***	0.001***	0.001***	0.001***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
'Government Effectiveness'	0.01	0.10	0.11	−2.19**
	(0.09)	(0.10)	(0.09)	(0.86)
RAI	−0.02***	−0.01**	−0.01**	−0.12***
	(0.004)	(0.005)	(0.004)	(0.02)
Constant	0.44**	0.24	0.16	7.14***
	(0.20)	(0.21)	(0.21)	(1.69)
R^2	0.40	0.42	0.43	0.57
Adjusted R^2	0.40	0.41	0.42	0.55

Note: *p<0.1; **p<0.05; ***p<0.01

the regions had expected positive relation besides Europe and Central Asia (EU & CA), this is counter-intuitive, but this could be because of relatively slow increase in the population and high rate of decarbonisation trends in the European countries [126]. Although % change in GDP per capita didn't have any significance in the main analysis, however, it seems to play a role in all the regions besides Latin America & Caribbean (LA & C). The relation in both East Asia & Pacific and North America (NA) had negative elasticities and interestingly, Europe and Central Asian cities had positive relation, implying that economic transformation in the regions had a different impact on the CO_2 emissions.

Table 3-8: Regression analysis in different regions

	Dependent variable:			
	Emissions change (%), total (tCO2)			
	EU & CA	**EA & P**	**NA**	**LA & C**
C40	0.12	−0.01	−0.25	0.18
	(0.27)	(0.24)	(0.28)	(0.31)
National emissions	2.33***	1.19***	4.05***	1.29***
	(0.33)	(0.18)	(0.29)	(0.25)
Population	−0.25**	0.24**	0.32***	0.72***
	(0.12)	(0.09)	(0.07)	(0.25)
GDP per capita ($)	0.18*	−0.15*	−0.22***	0.11
	(0.10)	(0.09)	(0.08)	(0.10)
Avg. Annual Heating Degree Days	0.003***	0.002	0.001***	−0.0002
	(0.001)	(0.002)	(0.0003)	(0.0002)
Avg. Annual Cooling Degree Days	0.001***	0.0005*	−0.0001	−0.0000
	(0.0002)	(0.0002)	(0.0001)	(0.0002)
Government Effectiveness	3.16***	3.35***		
	(0.93)	(1.06)		
RAI	−0.29***			
	(0.05)			
Constant	−0.38	−5.41**	1.70***	−0.72
	(2.11)	(2.27)	(0.35)	(0.67)
R^2	0.51	0.87	0.47	0.81
Adjusted R^2	0.48	0.83	0.46	0.71

Note: *p<0.1; **p<0.05; ***p<0.01

Analysis at city urban level

The analysis on breaking down per city type leads to fascinating results. First, C40 membership didn't have any significance in any of the city types. The effect of country emissions was significant throughout, however, the effect in the Medium size urban areas (e.g. Copenhagen, Venice, Utrecht, etc.) was the highest, conversely, Metropolitan areas (e.g. Perth, Oslo, Rotterdam, etc.) showed the lowest impact from the national emissions trend. Interestingly, the % change in CO_2 emissions was only driven in Metropolitan areas, where a % increase in population would account for a 0.25% increase in CO_2 emissions. Also, the effect of % change in GDP per capita was only evident in the Large metropolitan areas (e.g London, Bogotá, Paris, etc.) where a % increase would result in a decrease in CO_2 emissions by 0.58%. This can potentially be accredited to the fact that "pioneer" cities are already better suited for funding and also have more access to the innovative technologies needed to bring about incremental or reformistic changes (such as incentives for green business, renovation of system, etc.) despite the rising population in cities. No reductions were observed from average heating degree days in the cities, on the contrary, average cooling degree days had a very slight decrease in the % change in emissions, despite causing an increase in both Medium size urban areas and Small urban areas (Zwolle, Lausanne, Heidelberg, etc.). Surprisingly, a % increase in the government effectiveness (or capacity) showed variation in different categories of cities. For Large metropolitan areas, a % increase would account for an increase of almost 3.5% in CO_2 emissions and 4.5% in Metropolitan areas, whereas, the only significant decrease was evident in the small urban areas where a % improvement resulted in a decrease in emissions by 3%. The effect of RAI was only prominent in Metropolitan areas and Medium size urban areas, where a unit increase resulted in a decrease in CO_2 emissions by 0.09 % and 0.19% respectively.

Analysis of results by decade

I subdivided the sample by decade (2001-2010, 2011-2019) to perform the analysis using the data model prepared to assess the dynamics of the parameters, i.e., if the effect of each determinant has changed during the time period under analysis. Table 3-10 shows the results for the complete sample. Another rationale for conducting this analysis is to check whether C40 membership may have been effectual in the latter years, considering the organisation was established in 2005. However, the C40 cities had not seen any reductions for both periods C40 cities observed 0.49% and 0.004% higher emissions for both decades respectively. Certain affairs can be interpreted from the parameters for results. First, the parameter for the period 2011-19 presents lower values, and a less significant parameter, contrary to the period 2001-2010 where all the parameters are significant. In this regard, one thing to take into account is that the latest large financial crisis is encompassed by this period, and post-effects of the same may have influenced the results. Second, the C40 cities showed lower emissions in the latter decade, but from the main analysis, it was evident that C40 membership had no significant relationship in reduction of emissions. Therefore, it can be implied that the findings from the analysis are robust and C40 membership is merely symbolic in the empirical results.

Table 3-9: Regression analysis in different city urban areas listed in sequence from left to right: Large Metropolitan Areas, Metropolitan areas, Medium size urban areas and Small urban areas

	Dependent variable:			
	Emissions change (%), total (tCO2)			
	(1)	(2)	(3)	(4)
C40	−0.18	0.20	0.13	1.49
	(0.15)	(0.40)	(0.73)	(1.00)
National emissions	0.94***	0.83**	2.37**	1.42***
	(0.21)	(0.35)	(1.05)	(0.50)
Population	0.05	0.25***	0.14	0.16
	(0.11)	(0.09)	(0.12)	(0.16)
GDP per capita ($)	−0.58***	0.04	−0.06	0.06
	(0.10)	(0.10)	(0.10)	(0.16)
Avg. Annual Heating Degree Days	−0.0002	0.0003	0.003***	0.004***
	(0.0002)	(0.0003)	(0.0004)	(0.001)
Avg. Annual Cooling Degree Days	−0.0004***	−0.0002	0.0003***	0.001***
	(0.0001)	(0.0001)	(0.0001)	(0.0002)
Government Effectiveness	3.47***	4.48**	−0.15	−2.59**
	(0.98)	(1.73)	(2.48)	(1.11)
RAI	−0.02	−0.09*	−0.19*	−0.06
	(0.03)	(0.05)	(0.11)	(0.06)
Constant	−2.95	−4.20	4.85	3.91
	(2.20)	(3.90)	(5.91)	(2.60)
R^2	0.83	0.66	0.58	0.57
Adjusted R^2	0.80	0.63	0.54	0.50

Note: *p<0.1; **p<0.05; ***p<0.01

Table 3-10: Analysis of results by decade

	Dependent variable:	
	Emissions, total (tCO2)	
	2001-10	**2011-19**
C40	0.49**	0.004*
	(0.22)	(0.002)
National emissions	0.49**	1.18***
	(0.21)	(0.01)
Population trend (number of inhabitants)	0.75***	−0.0002
	(0.10)	(0.001)
GDP per capita ($)	−0.07**	0.0004
	(0.03)	(0.0004)
Avg. Annual Heating Degree Days	0.001**	−0.0000
	(0.0004)	(0.0000)
Avg. Annual Cooling Degree Days	−0.001***	0.0000
	(0.0001)	(0.0000)
Government Effectiveness	2.05***	0.65***
	(0.38)	(0.01)
RAI	−0.12***	−0.07***
	(0.03)	(0.001)
Constant	5.33***	1.67***
	(1.05)	(0.04)
R^2	0.44	1.00
Adjusted R^2	0.42	1.00

Note: *p<0.1; **p<0.05; ***p<0.01

3.2.2 Diagnosis

After performing the regression analysis, diagnostics are performed to evaluate if the model selected i.e., *Model 7* works well for the data at hand. To do so, the residual errors of the model are analysed. The "residuals" are what is left over after fitting a model. The residuals are equal to the difference between the observations and corresponding fitted values:

$$e_i = y_i - \hat{y}_i \tag{3-3}$$

where (e_i) is the residual for the city i and ($\hat{y}_i$) is the fitted value from the model. The fitted (or predicted) values would be the percentage change in emissions for city i (E_i) for the given control variables 3-1, which means for a given value of control variables, the observed emissions for the city i can be overestimated or underestimated. This difference in the predicted value from the regression line is equal to the residual errors. The aim of the diagnosis is to ensure the underlying assumptions of linear regression are satisfied, such as:

- **Linearity of the data**: The relationship between the predictors and the outcome is assumed to be linear.

- **Normality of residuals**: The residual errors are assumed to be normally distributed.

- **Homogeneity of residuals variance**: The residuals are assumed to have constant variance (homoscedasticity).

- **No Multicollinearity**: Multiple regression assumes that the independent variables are not highly correlated with each other.

To ensure these assumptions hold true, potential problems can be checked by visualizing the residual errors through diagnostic plots. Fig. 3-13 shows the residual in four different ways:

- **Residuals vs Fitted**: The linearity assumption can be inspected using this plot. Ideally, we would want to have no distinct patterns and the cluster to be distributed towards the middle of the plot. The residuals "bounce randomly" around the 0 line, this suggests the assumption of linearity between the predictor and outcome variable is reasonable. Also, the red line roughly forms around the 0 line, suggesting that the variances of the error terms are equal.

- **Normal Q-Q** Used to examine whether the residuals are normally distributed. It's good if residuals points follow the straight dashed line. In our case, almost all the points fall along the reference line, so we can assume the normality of residuals. Although, there are potential outliers in the dataset which are evident in all four plots.

- **Scale-Location (or Spread-Location)** Used to check the homogeneity of variance of the residuals (homoscedasticity). A horizontal line with equally spread points is a good indication of homoscedasticity. This is not the case in our example, where we have a heteroscedasticity problem. To confirm this, Breusch-Pagan Test [127] was used to determine if heteroscedasticity (unequal scatter of residuals) is present in regression
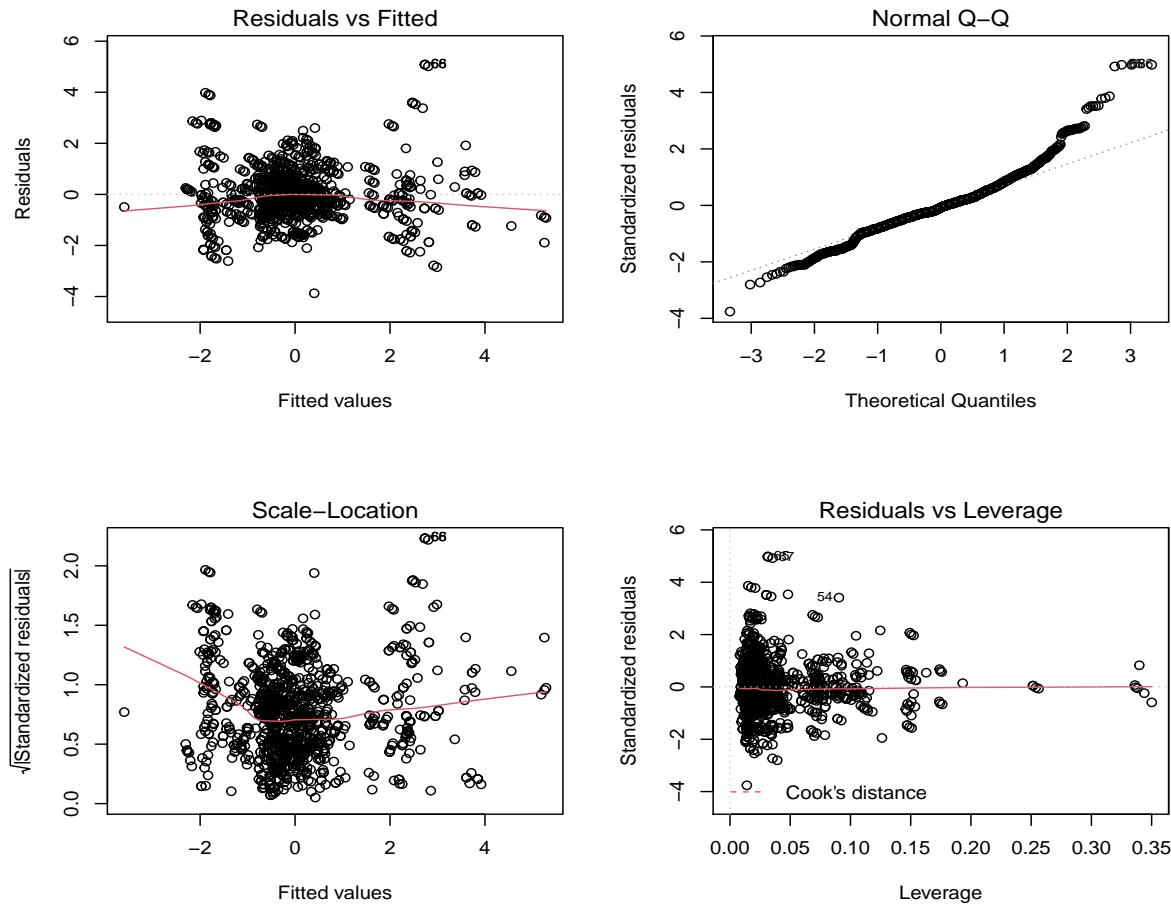
Figure 3-13: *Diagnostic Plots*

analysis. The null hypothesis says that homoscedasticity is present. The test yields p-value less than 0.05, concludes that heteroscedasticity exists in this model by rejecting the null hypothesis.

- **Residuals vs Leverage** Used to identify influential cases, that is extreme values that might influence the regression results when included or excluded from the analysis. The influential observation can be defined as an observation that changes the slope of the line [128]. On the plot, when the points are outside of the Cook's distance, this means they have high Cook's distance scores, implying that these observations are influential to regression results. Another thing to consider is to see if any case or cases cluster on the upper or lower right corner. In our case, the Cook's distance lines (a red dashed line) is barely visible as all the cases are well inside of the Cook's distance lines, implying there is no influential case or cases.

It can be concluded that the model fits the dataset at hand and has a linear relationship between the predictors and the outcome. Although the diagnosis reflected the presence of outliers and heteroscedasticity in the model, however, they do not necessarily cause a problem

in this case as they do not change the actual estimates of the analysis. The outliers are validated by comparing their emission change from their regional inventories, therefore it's not due to miscalculation or reporting error, making them essential to acknowledge in the dataset. Another point to consider is that the variables have been transformed into percentile ranges which are relatively more resistant to outliers. Although the presence of heteroscedasticity is not conventionally big, Table 3-11 compares the orignal model (OLS) and a weighted least square (WLS) regression which is sensitive to the effects of outliers, as it defines the weights in such a way that the observations with lower variance are given more weight. It can be concluded that the presence of heteroscedasticity does not have any significant impact on the results as the findings didn't change at all.

Table 3-11: OLS vs WLS

	Dependent variable:	
	Emissions change (%), total (tCO2)	
	ols	**wls**
C40	0.01	0.004
	(0.18)	(0.18)
National emissions	1.74***	1.78***
	(0.17)	(0.18)
Population trend (number of inhabitants)	0.21***	0.19***
	(0.06)	(0.06)
GDP per capita ($)	−0.06	−0.05
	(0.05)	(0.06)
Avg. Annual Heating Degree Days	0.001***	0.001***
	(0.0002)	(0.0002)
Avg. Annual Cooling Degree Days	−0.0000	0.0000
	(0.0001)	(0.0001)
'Government Effectiveness'	−2.19**	−2.09**
	(0.86)	(0.82)
RAI	−0.12***	−0.12***
	(0.02)	(0.02)
Constant	7.14***	7.05***
	(1.69)	(1.63)
R^2	0.57	0.56
Adjusted R^2	0.55	0.54
Note:	*$p<0.1$; **$p<0.05$; ***$p<0.01$

Chapter 4

Qualitative Analysis

The statistical analysis revealed that there is no statistically significant correlation between C40 membership and CO_2 emissions in the OECD cities. Although, establishing a clear link between cities climate actions and emissions reductions remain a challenging task as highlighted in the previous studies [129, 35]. It is necessary to have a complementary approach to establish the relation of the climate network on climate mitigation along with the empirical research, to have a comprehensive basis to establish the findings. The qualitative analysis using case studies would be used to answer the *SQ3* which is: *" How does C40 membership affect municipal climate work and aid in climate mitigation?"*. This chapter focuses on how C40 membership affects different cities and aim to investigate the effectiveness of membership on climate action plans from ambition to the outcome.

The final research question i.e. SQ3 is to identify and single out the exact role of C40 network membership in local climate action plans focusing on mitigation. This sub-question is answered using cross-case analysis, where two cases are analysed: Copenhagen and Bogotá using the integrated research framework. Before, diving into the case studies, this chapter starts with synthesizing the research framework for the analysis, followed by the research design and methodology. Lastly, the implications of the findings will be discussed and explained with variance and similarities in the selected cases with respect to the research framework.

4.1 Analytical frameworks

Cities can adopt various governance methodologies to tackle climate mitigation and adaptation issues. Followed by the commitment of taking action, cities can have different delivery routes to action and can use different levels and mechanisms to influence climate action. Although climate action plan provides comprehensive roadmaps to the emissions reductions, the organisation and implementation of climate action can be analyzed from various perspectives. Also, the availability and variety of existing frameworks both in academia and industry for climate actions clouds a researcher's capacity to evaluate what has actually been implemented and if they have achieved measurable reductions in emissions or not [106].

To understand the progress and implementation of climate action, Hale et al. [5] conceptualised a framework as shown in Fig. 4-1. This framework fits well for exploring the potential factors where C40 affects or influences the municipal organisation on two accounts; first, it adds structure to the climate work defined by indicators and their natural progression in terms of climate action, second, it allows to understand what, where and how the intervention is happening concerning C40 and finally, what outcomes are measured and establishing the impact of C40 along the value chain. The framework also allows to establish whether *substantive progress* has been achieved in terms of climate mitigation which can be measured directly against the emission targets and change in emissions since the baseline year. For mitigation, setting up targets *ambition* in alignment with the Paris Agreement's goals of limiting warming to well below 2°C, or even 1.5°C or the net zero emissions target before 2050. It is also worth mentioning that if the adopted target is ambitious, it may be the case that the impact along the framework would be large, but do not necessarily result in the intended outcome or vice-versa. Similarly, *robustness* reflects the municipal capacity to achieve these targets and giving an estimate on the city's capacity to achieve those targets. The potential key indicators to measure this could be the presence of robust inventories, financial capacity, human resources, support from different stakeholders, etc. all the functional attributes required for the implementation of the plan. Finally, the *implementation* has been explained as what has been successfully delivered as compared to what was promised or planned (realized versus planned). This can be tricky to evaluate due to unavailability of data, regardless, the adoption of key policies and implementation of mitigation projects are the key indicator to assess this.
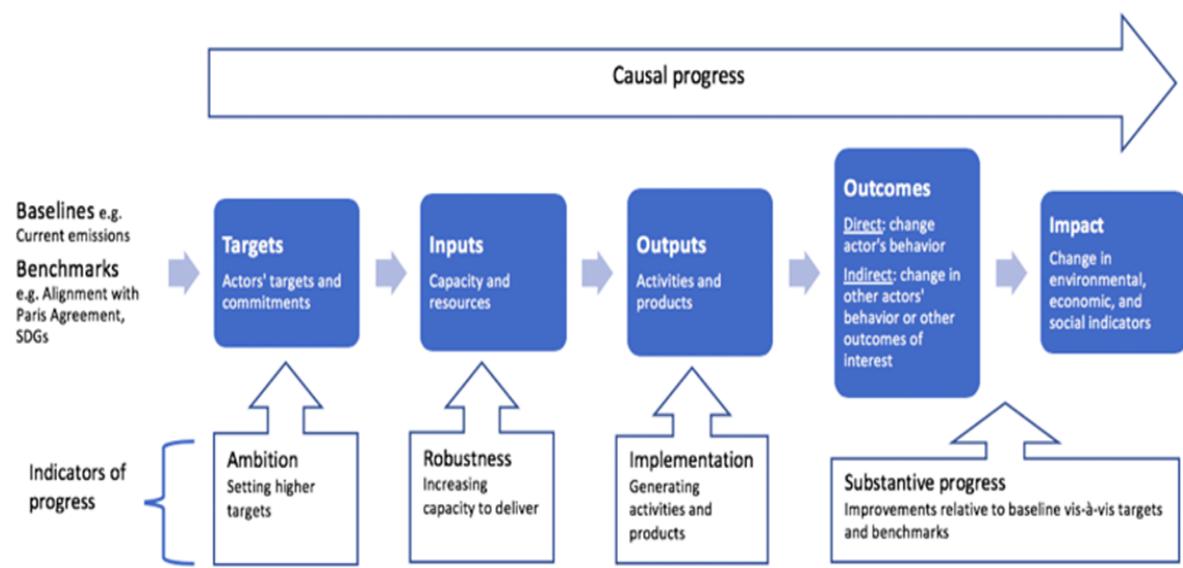
Figure 4-1: *Log frame model for measuring progress, implementation, and impact of climate action [5]*
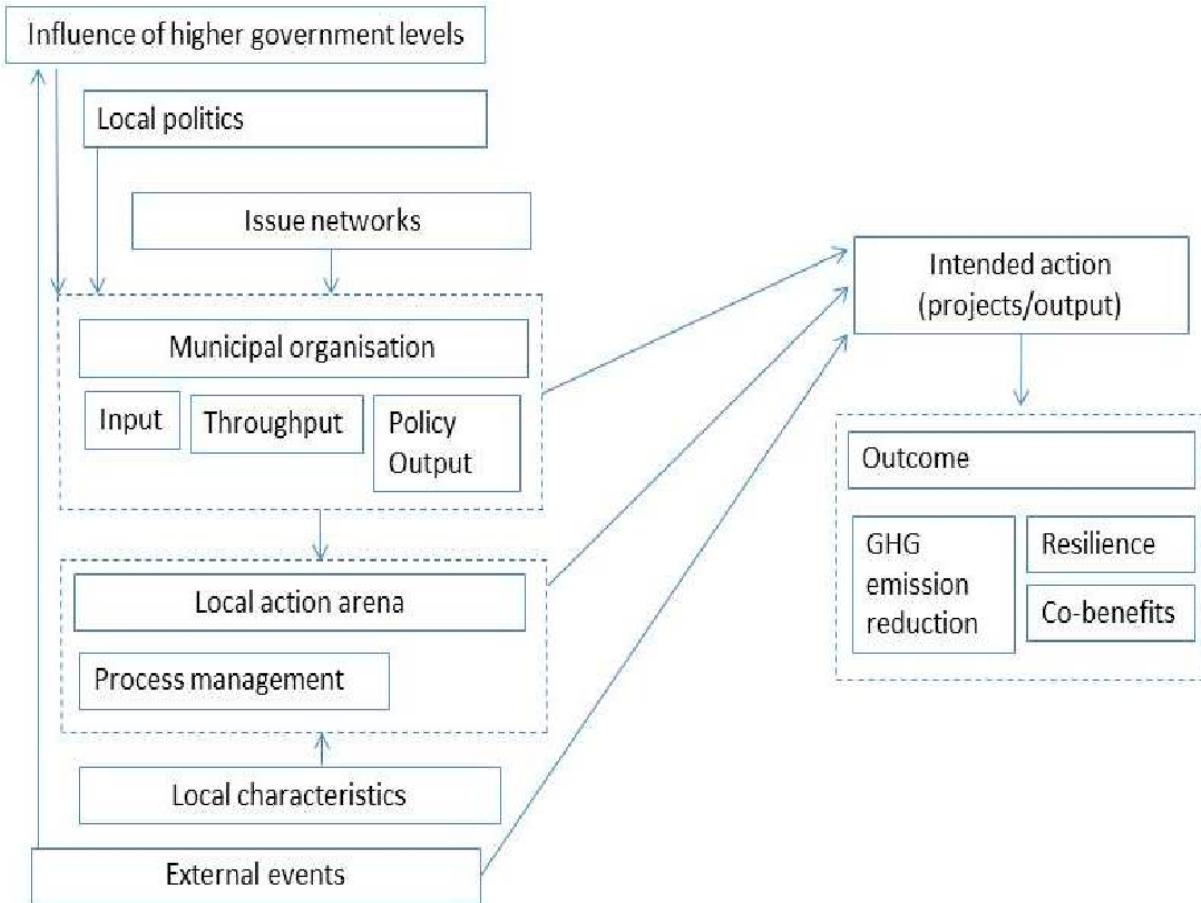
Figure 4-2: *Framework presented by Hopp et al, to analyse the local climate action [6]*

The log frame model provides a generic approach entailing various factors to evaluate the impact of either sub or non-state climate action. It is important to note that the log frame model only considers intra-municipal factors and transnational governance is a complex multi-governance scale system. Therefore, to understand the role of C40 on different conceptual clusters at interplay beyond the municipal organisation, I combined the factors or concepts from the Hoppe et al. [6] framework, which is an analytical framework on the local climate action of the municipalities with the log frame model. Fig. 4-2 shows the schematic diagram and the interplay between the municipal work and different exogenous conceptual clusters such as geopolitics, partnerships with private stakeholders, support from the national government, etc. As noted from the framework, the dynamics between various heads of multi-level governance on the local climate action is essential to take into account, as cities may lack jurisdictional authority to address a certain sector or may lack sufficient capacity for implementation of policies. This framework allows the researcher to analyze the local climate action and climate change policy through the factors or clusters, both internal and external, that influence the climate action at the municipalities. In the context of this research, a set of key clusters are selected which C40 potentially have a direct or indirect influence on. The framework itself identifies C40 under the *External issue network*, which had a direct effect on

the municipal organisation. However, chapter 2 reflects on C40 capabilities and engagement in lobbying and advocating activities for climate action, hence it can be argued that C40 may possess an indirect relationship with other clusters. The selected key variable clusters are as follows: *Municipal organisation*, *Influence of higher government levels*, *Output viz. Intended climate action*, *Major external events* and *Outcome*. The *Municipal organisation* is further subdivided into: *Input*, *Throughput and Output*. The *Influence of higher government levels* has been recognised by many scholars in academia, as cities are heavily dependent on the frameworks and institutions provided by the central, regional and provincial governments. The *Outcome* is identified as a separate cluster beyond the municipal organisation, which is the final impact of implementation, e.g., lowering of emissions, increase in adaptation capacities, etc. Although *Major external events* is a cluster where no climate network may have any direct or indirect relationship, it is still considered as the impact of the event (e.g., war, financial crisis, pandemic) can be significant within the value chain.

It is to be noted that Hale's framework indicators entail some overlapping concepts that need to be presented as mutually exclusive entities or clusters to give nuances to the analysis. The *input* indicators in both the frameworks incorporate the same definition. Another important factor to consider at the municipal organisation is *throughput* which is a wide set of internal organisational, managerial and process factors impacting the local climate work in the municipalities [6]. The *implementation* indicator cannot be considered as the output referencing Hoppe's framework, hence *output* pertains to the levers and incentives used by cities to achieve the outcomes. Hence, *implementation* indicator is more fitting with the *Output viz. Intended climate action* cluster and is considered a separate indicator from the output in the research framework. Table 4-1 shows the amalgamation of the two frameworks and the selected key indicators to establish the C40 intervention to answer the SQ3. It is also important to acknowledge the limitations of this approach. The log model framework assumes a linear flow in the progress, but as explained in Hoppe et al. framework, exogenous factors are impacting the municipal climate work which are taken into consideration in the research framework, however, establishing the co-relations of the indicators and at what stage of municipal organisation these external factors interact is out of the scope of this analysis. I intend to utilize this integrated research framework to see the relationship of C40 membership on these indicators and how the intervention is taking place and if or how it varies between the different characterisation of its member cities.

4.2   Research Design and Methodology

In this section, the key features of the study's research design, case selection, data collection and data analysis will be presented. The research design for the qualitative study encompasses two case studies within the C40 cities network. Each case study was carefully analysed focusing on the relevant climate policy, climate projects and climate actions in regard to mitigation using the integrated research framework.

4.2.1   Case Selection

The cases selected are based on the statistical analysis presented in chapter 3 and the selection criteria presented by *Seawright & Gerring* [45]. According to the theory, *"Deviant"* cases

Table 4-1: Integrative research framework adopted from [5, 6] with key indicators impacting the climate action in municipalities

Factors impacting local climate work	Key indicators	Adopted from
Ambition	- Level and type of target - Intermediate milestones	[5]
Input	- Financial resources - Existence of inventories - Adequate human resources - Regulatory authority	[5, 6]
Throughput	- Political support - Commitment (by staff) - Knowledge management - Inter-department coordination - Monitoring and evaluation	[6]
Output	- Policy instruments - Municipal governing typology	[6]
Influence from Higher Government Levels	- Policy linkage between national and local - Presence of support schemes	[6]
Major external events	- Geo-political events - Geo-physical events - Economic crisis	[6]
Implementation	- Adoption of key policies - Implementation of projects	[5, 6]
Outcome	Direct - Change in emissions Indirect - Resilience - Climate co-benfits	[5, 6]

are selected for exploratory or confirmatory of a phenomenon entailing the full range of variation in the case of interest. Fig. 4-3 shows the estimation of CO_2 emissions in C40 cities in the data based on actual against the predicted values from the modelling. The two cases selected for this study are *Bogotá* & *Copenhagen*, representing a full variation of the % change in CO_2 emissions, but also exhibit reasonable diversity in other parameters such as population, size, geography, and institutional dynamics. In addition, the cases depict significant diversity within the C40 network as well, for example, Bogota is an honourable representative of the steering committee and is signatory under "Megacities" membership, while Copenhagen is part of "Innovator cities" membership. The cases selected also covers the economic differences between global north (Copenhagen) and global south (Bogotá) cities, which makes the investigation fascinating as if and how the C40 membership differs for north-south cities.
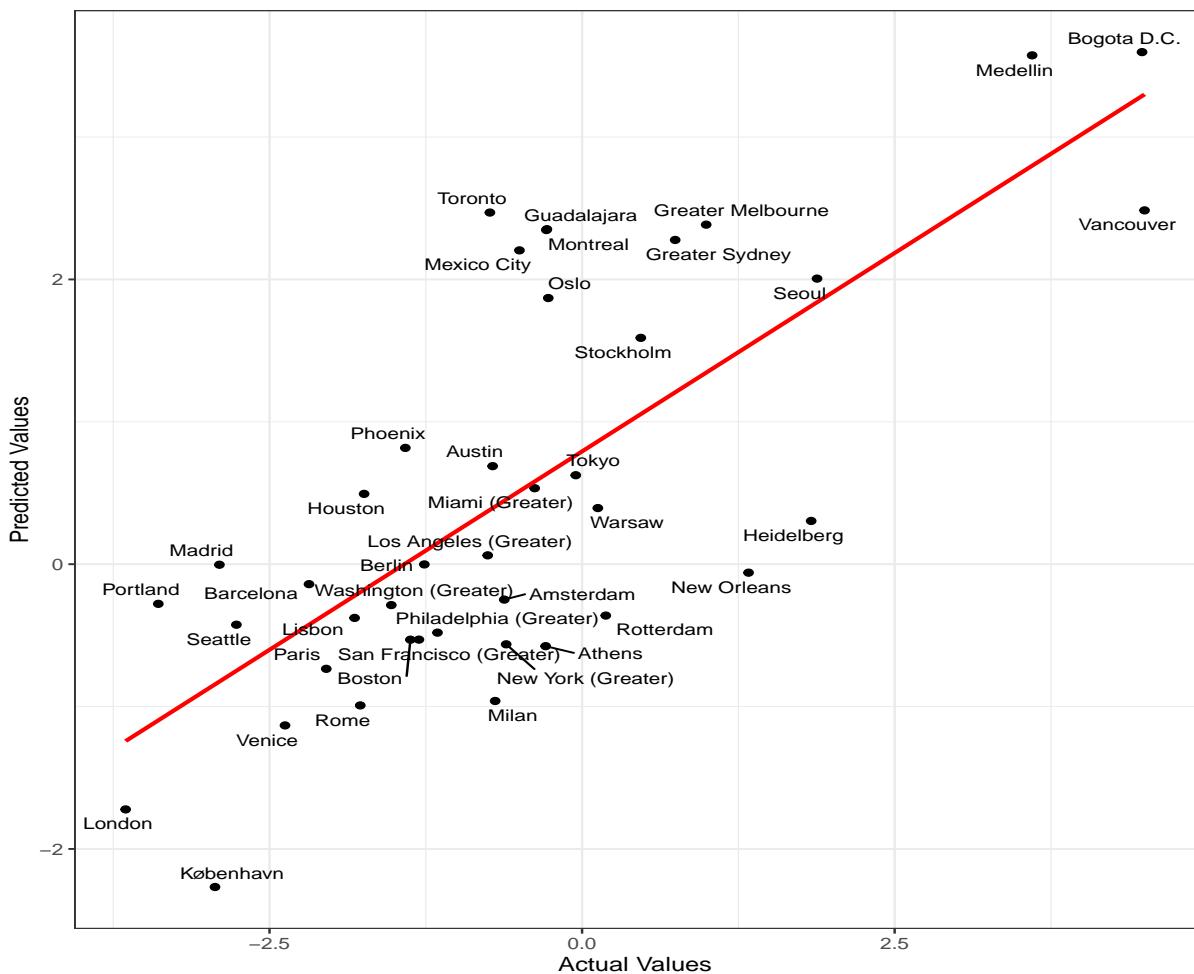
Figure 4-3: *Model 7 estimation of CO_2 emissions in C40 cities*

4.2.2 Data Collection

Data used in this research is mainly deduced from the interviews (primary data) online documents (secondary data). The secondary data was collected from multiple resources which include articles, publications, C40 specific documents, and websites. Interviews are key in obtaining case study information [130]. In identifying the potential people for the interview, a self-made criteria and snowballing method was used to identify people and make contact for the interview. For each municipality, at least two interviews were conducted, either a C40 representative, a public official or a researcher. The C40 has a very limited number of staff, so it was not difficult in identifying the right people to reach out to. In the attempt to have a holistic view on the problem, the researchers with expertise on TMNs or worked with cities or TMNs was the criteria in selecting the researchers. The public official was mainly characterized as someone who has a broad overview on the climate policies and how it is organised.

The interviews conducted were semi-structured, the questions for the interview were based on the research framework (see Fig. 4-1) and the duration for the interviews was from 30-60 minutes. The interview questions were deduced based on the research framework, where the clusters or concepts were used in the questionnaire. The questions were left open-ended on purpose to foster participation and free flow of communication. In total 6 interviews and 1 focus group were carried out via Zoom. For Copenhagen, 4 interviews were conducted including a C40 representative from Copenhagen's office, two researchers with an extensive background in TMNs and a former municipal servant in the Technical administration of Copenhagen and currently working with DK2020 project. Whereas, for Bogotá, a focus group was conducted with the municipality of Bogotá with a total of 7 participants belonging to different departments such as international relations, transport, etc, a professor from Colombia with a research focus on TMNs in the context of Latin America and finally, a C40 representative working with Latin American cities.

In the interviews, participants were first asked about the role of the C40 network in increasing the ambitions of the municipality's climate activities. After this; the questions covered dealt with understanding how the C40 network may have impacted the organisation of climate work considering the three sub-clusters in the research framework. and the broader role of C40 in the context of climate mitigation and its relevance with the exogenous indicators of the framework. The interviews were conducted virtually face to face but followed a fixed themes with each interviewee. Prior to the interview, the interviewee(s) were given a consent form to seek their formal consent on the usage of the information provided, however, some of the interviewees did not agree to the transcription of the recorded interview. The identity of each interviewee is kept anonymous where applicable; the transcripts of the interview is shown in Appendix B.

4.2.3 Data Analysis

To investigate the effectiveness and efficiency of the C40 network in the climate mitigation of municipalities, data collected was critically reflected upon with series of iterations in the analysis and their interpretations. For each study, case reports were prepared (see section 4.3) and the data were analyzed using Atlas.ti in terms of categories or themes using the research framework to conduct the cross-cases analysis. The coding scheme reflected the concepts from

the research framework, and after carefully analysing the content, a coherent narrative was built for each indicator reflecting upon the two cases.

The rationale for cross-case analysis is to mobilise the knowledge from the various member of C40 cities having significant differences to find out how the role of C40 differs in within its network cities and where the intervention seems to be effective or ineffective. Moreover, the research framework allows checking whether the network membership is associated (directly or indirectly) with the indicators. The comparison in the analysis is performed using the qualitative indicators ranging from '--' for poor influence, to '++' for strong influence of C40 membership concerning the research framework in an attempt to establish the relationship with indicators.

4.3   Case histories

This section describes the selected cases based on their climate history, institutional dynamics, regional authority and climate action plans.

4.3.1   Københavns Kommune

Copenhagen is the capital and most populous city of Denmark. It is situated on the eastern coast of Zealand, along the Øresund strait. The Copenhagen municipality is also known as (Københavns Kommune) is led by Lord Mayor Lars Weiss, appointed in October 2020. The population of the core area is 580,184 inhabitants and a GDP of 111 billion USD in the year 2015. Copenhagen witnessed an average annual rainfall of 613 mm/year with an average temperature of 8.0 °C, putting Copenhagen under extreme weather risks such as storms, sea-level rises and coastal flooding. Copenhagen holds a permanent C40 office which was opened in 2017 by the previous Lord Mayor Frank Jensen, which serves as a centre for "the network's global Business, Economy and Innovation programme [131]". Copenhagen is admitted under the innovator city membership and belongs to three sub-networks in C40: Transportation & urban planning, Food, waste & water and Adaptation & implementation profile. The Mayor's jurisdiction covers the area of 86 km^2 and Fig. 4-4 shows the distribution of Mayoral powers in the city. The mayor holds relatively strong powers in almost all of the listed sectors within the city, from operating, enforcing policies to budgeting and financing needed for the plans. Although, this analysis from C40 does not reflect on the complete picture as important sectors such as Industries and Private transport are omitted which are accountable for significant emissions within the city boundaries. Besides the C40 Cities climate network, the city also participates in other TMNs such as Covenant of Mayors, the Compact of Mayors and Carbon Neutral Cities Alliance.

Denmark has been very successful in the energy transition since the mid-1970s, establishing a robust, decentralised energy system which is one of the highest in the European Union [132, 133]. In the same regard, Copenhagen has undergone a significant transition with, 98% of households connected to the district heating system, and the energy is mainly supplied from combined heat and power (CHP) technologies and waste-to-energy facilities [8]. Besides that, Copenhagen has been very efficient in spatial planning and infrastructure with high accessibility to public transport and excellent infrastructure for bicycling lanes [134].

	own and operate	set and enforce policies	budgetary and revenue control	set vision
Private Buildings				
Public Buildings				
Energy Supply				
Finance & Economy				
Public Transport				
City Roads				
Urban Land Use				
Waste				
Water				

not available   not applicable   limited powers   partial powers   strong powers
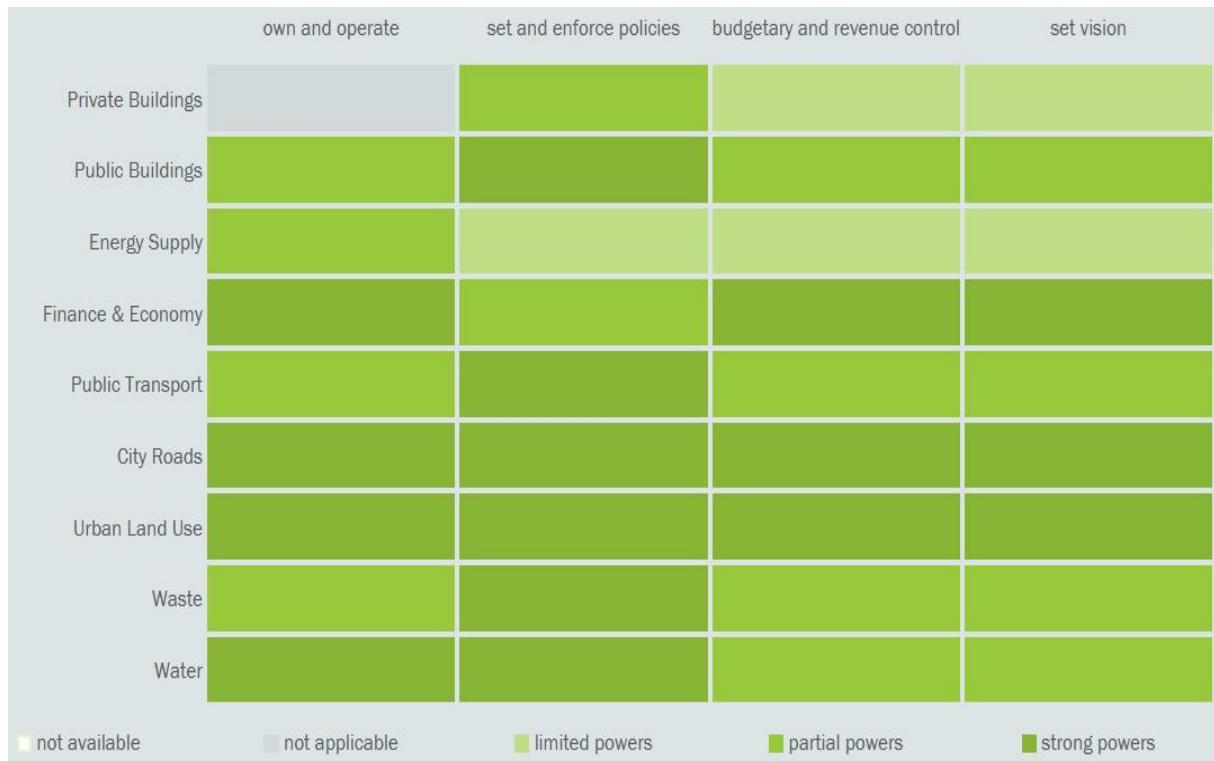
Figure 4-4: *Mayoral powers in the city of Copenhagen [7]*

The municipality has adopted three climate action plans (CAP) in the last two decades. Fig. 4-5 represents the different CAPs adopted by the municipalities. The CAPs uses geopolitical jurisdiction as the spatial boundary and calculates emissions occurring within the municipal boundaries and grid-related energy emissions (i.e scope 1 and scope 2 emissions) [135]. The mitigation initiatives associated with the largest expected emissions reductions in all the three CAPs are district heating system, fuel switching from coal to biomass, wind energy expansion and waste incineration [136]. Although, the first two CAPs had more initiatives concerning district heating and the recent initiatives are more focused on promoting fuel switching in transport and on integrating wind energy in the electricity grid. The latest CAP wants Copenhagen to become the world's first carbon-neutral capital city by 2025 [136]. Prior to the Paris Agreement in 2015, Copenhagen has a dedicated history of been engaged in climate change and ambitious targets with significant reductions that took place from the period of 2005-2015 owing to their previous two CAPs [136]. The main source of emissions within the city boundaries is the energy sector, therefore the majority of the initiatives in the CAPs are focused on the energy sector, with a total of 51 mitigation initiatives in the energy supply [8]. The CAP (2012) has four pillars: energy consumption, energy production, mobility and city administration initiatives. The third CAP makes distinction in the implementation where the first phase of implementation in 2013-2016, the second in 2017-2020 and the final phase in 2021-2025 [136]. Each implementation is followed by an evaluation and priorities and results are declared by the municipality. The key takeaway from the first evaluation is that Copenhagen is under its way to the 2025 target, although additional measures are needed to achieve their ambitious targets, owing to some national measures such as congestion zone and

changes to energy taxes failing to materialize. On the contrary, progress at the national level on wind power and biomass has exceeded the expectations and reductions have been achieved considerably faster than envisioned [136].
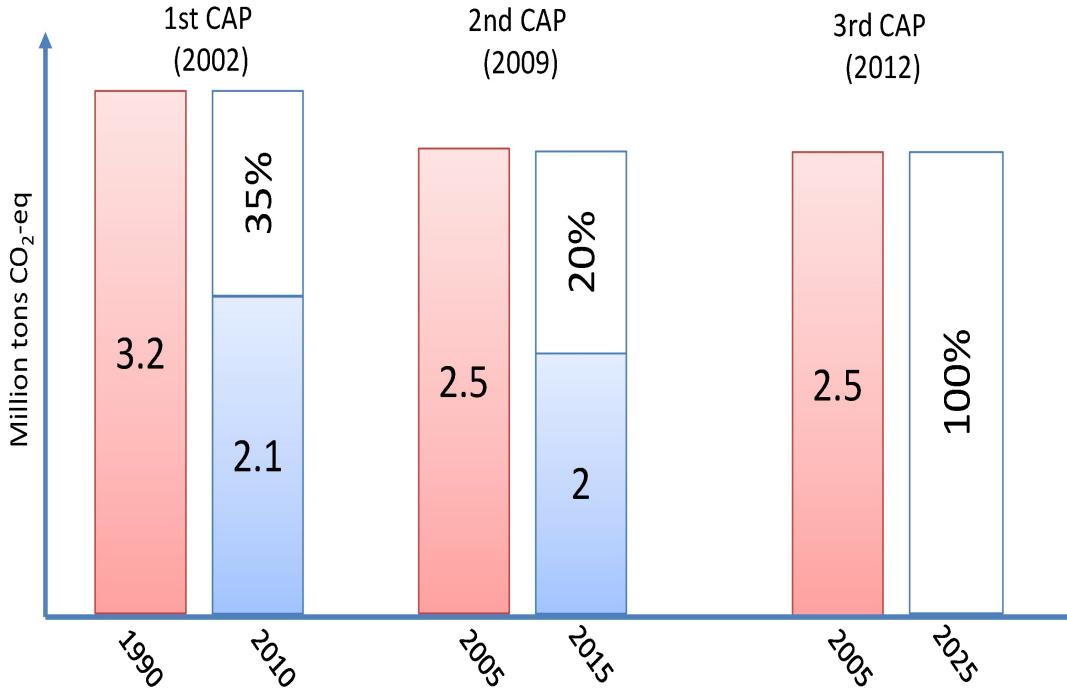
Figure 4-5: *Intended target levels of Copenhagen adapted from their CAP. The red columns are the base year emissions, the white boxes are the intended % reduction in emissions and blue boxes are the remaining emissions in the target year [8]*

The in-depth research performed by Damsø et al. [8] concluded that Copenhagen has displayed high overall implementation performance vis à vis in energy supply and emissions reduction. The evaluation report of 2016 also showed they have overachieved their targets in 2015 and is on track to meet their emission neutrality target by 2025 (in the context of Copenhagen, offsetting local fossil fuel consumption with enough production of renewable energy). The Copenhagen municipality assesses the GHG emissions as the bottom-line for establishing success from the measurable outcomes. The majority of the initiatives have been implemented by the municipality itself such as CHP on biomass, carbon-neutral buses, the establishment of wind turbines, etc., and some in collaboration with other stakeholders, aiming at fostering participation from the citizens [136]. The roadmap from 2017-2025 listed by the city of Copenhagen describes 60 initiatives which correspond with the four main pillars of their CAP [136]:

- **Energy production:** Initiatives focusing at installing wind turbines within the city and other municipalities, as well as focusing on other power generations technologies such as biomass, treatment of organic waste and ensuring district heating is carbon neutral. The expected reductions to come from this area is expected about 80% reduction.

- **Energy consumption:** Initiatives focusing on reducing heat and electricity consumption from commercial (20%) and residential buildings (10%) explicitly. The principle

initiative includes the 'Energy Leap' project which encourages building energy efficiency improvements with building targeting to have E, F or G energy label buildings.

- **Green mobility:** Initiatives focused on transforming the public transport and cycling infrastructure through partnerships and promotion. The intended initiatives aim at promoting new fuels like hydrogen and biofuels, establishing intelligent traffic management, and influencing behaviour change through mobility programmes and 'attitude training'. The target is to have 75% of all trips on foot or by bike or from the public transport in Copenhagen - up from 66% in 2017. Flagship initiative includes Mobility as a Service (MaaS) which improves the accessibility of public transport and deploying carbon-neutral buses.

- **City administration initiatives:** Initiatives focused on reducing energy consumption by street lighting and municipal buildings by 40% also installing solar panels, green municipal fleets and sustainable procurement.

The city of Copenhagen appears to be on track and have achieved impressive reductions, however, it is still early to say whether 2025 climate-neutral plans will be successful or not and also, how the participation in TMNs would aid in the realisation of the targets.

4.3.2 Bogotá, Distrito Capital

The city of Bogotá, the capital district of Colombia, is one of the main megacities in Latin America with a population of 8.7 million inhabitants and one of the biggest economies in Colombia with a GDP of 188 billion USD. The city is located in the centre of Colombia and is led by the honourable mayor Claudia López, elected last year who is also the first female mayor in Bogotá's history. The mayor's jurisdiction in terms of population and area is 8.54 million people and 1595 km^2 respectively. Bogotá in total is part of 10 city networks and C40 admits Bogotá under the Megacity membership profile and also participates in three sub-networks of C40: Transportation & Urban planning, Food, waste & water and Adaptation & implementation. In addition, Bogotá is also part of the steering committee for C40. Besides Bogotá's socio-economic problems, climate change put Colombia's capital to extreme climate threats such as flooding, wildfire and mass movement [137].

Since the 1990s, the Colombian government has experienced a transition in their energy sector which was caused by market opening or decentralisation with clear separation of roles between investors and the government, prior national government had nearly absolute ownership of the electricity sector [138]. Although the city formally lies within the department of Cundinamarca, it is administered independently from the rest of the state and has a degree of autonomy where Mayor of Bogotá has relatively strong powers across many sectors including transport, built environment and water, as shown in Fig. 4-6. As mentioned already, this analysis is incomplete due to missing sectors.

Bogotá is responsible for 0.36% of global emissions, where each citizen is responsible for an average of 2.28 tons per capita of CO_2 emissions on average. Within the city boundaries, 64% of the city emissions comes from the energy sector (usage of fossil fuels such as coal, oil, natural gas), followed by waste accounting for 19.75% and remaining emissions from agricultural, forestry and land-use changes [139]. The major sectors where the energy demand

	own and operate	set and enforce policies	budgetary and revenue control	set vision
Private Buildings				
Public Buildings				
Energy Supply				
Finance and Economy				
Public Transport				
City Roads				
Urban Land Use				
Waste				
Water				

not available — not applicable — limited powers — partial powers — strong powers

Figure 4-6: *Mayoral powers in the city of Bogotá [7]*

in Bogotá comes from are: residential, industrial, transportation, services and others, where the transport sector has the highest share of emissions account for consumers 5.4 million tCO_2 i.e 47.4% of total emissions [138, 140].

Bogotá's climate action plan 2020-2050 was released this year, focusing on five strategic marco actions to achieve intended targets in climate mitigation, as well as adaptation   citeBogota-Plan. Although, it is to be noted that the CAP still hasn't been approved by C40, therefore it is expected to change to be aligned with the Paris agreement. The reported CAP enlists five goals revolving around: cutting down CO_2 emissions, save and manage water, increasing capacity of adaptation, foster collective actions and promote transformative cultural change in the society. The CAP reflects on Bogotá's ambitions, although the prepared plan lacks rigour in terms of implementation, resources required and monitoring progress. In the context of mitigation, Bogotá aims to cut their CO_2 emissions by 56% by 2038, 62% by 2050 and the intended goal for 2025 is to stabilize their per capita emissions by 2 tonnes as the upper limit [139]. The plans align with the Paris agreements, where Bogotá aims to become carbon neutral by 2050. Considering the majority of their emission comes from the transport sector, "14 out of the 45 initiatives of the CAP are related to the reduction of emissions, which also contributes to the improvement of air quality" said in a press release by the city council secretary [141]. The CAP aims to minimise the emissions from the transportation sector through, deploying innovative technologies in the public transport system and electrification of conventional city taxi's. Second, within the transport sector, the majority of the emissions comes from stationary sources (buildings, industries, etc.) and have positioned Bogotá as the Colombian urban area with the highest emissions by stationary sources [142]. The munici-

pality wants to increase the use of energy-efficient technologies, implement PV solar energy in various sectors and enforcing sustainable construction and reducing the carbon footprint of existing buildings which is a bit of an overlap with the adaptation plans. Furthermore, the aim is to have "zero waste" by implementing circularity in industrial processes, construction and thermolysis of the solid waste generated.

4.3.3 Case comparison

Both Copenhagen and Bogotá have developed an inclusive climate action plan aligned with the 1.5°C ambition of the Paris Agreement as a part of C40 leadership standards. Bogotá recently finished its climate action plan as part of the deadline 2020 and is yet to be reported by the municipality [Focus group B.7]. Both the cases show significant differences in their climate strategy, jurisdiction and local characteristics. It is evident from Fig. 4-7 that in my CO_2 emissions data set from 2001-2019, Copenhagen has achieved a greater reduction in total emissions relative to Bogotá which has increased its emissions owing to its increase in population and economic activity [138]. Although, the per capita emission of Bogotá is relatively lower due to significant differences in the population. Copenhagen success in a significant reduction in emissions can be credited to its early adopters of climate policy, indicating their ambitions against climate change and also, the supportive policies provided by the national government for district heating energy system back in 1979, which today accounts for the 98% of the heating supplied [143].
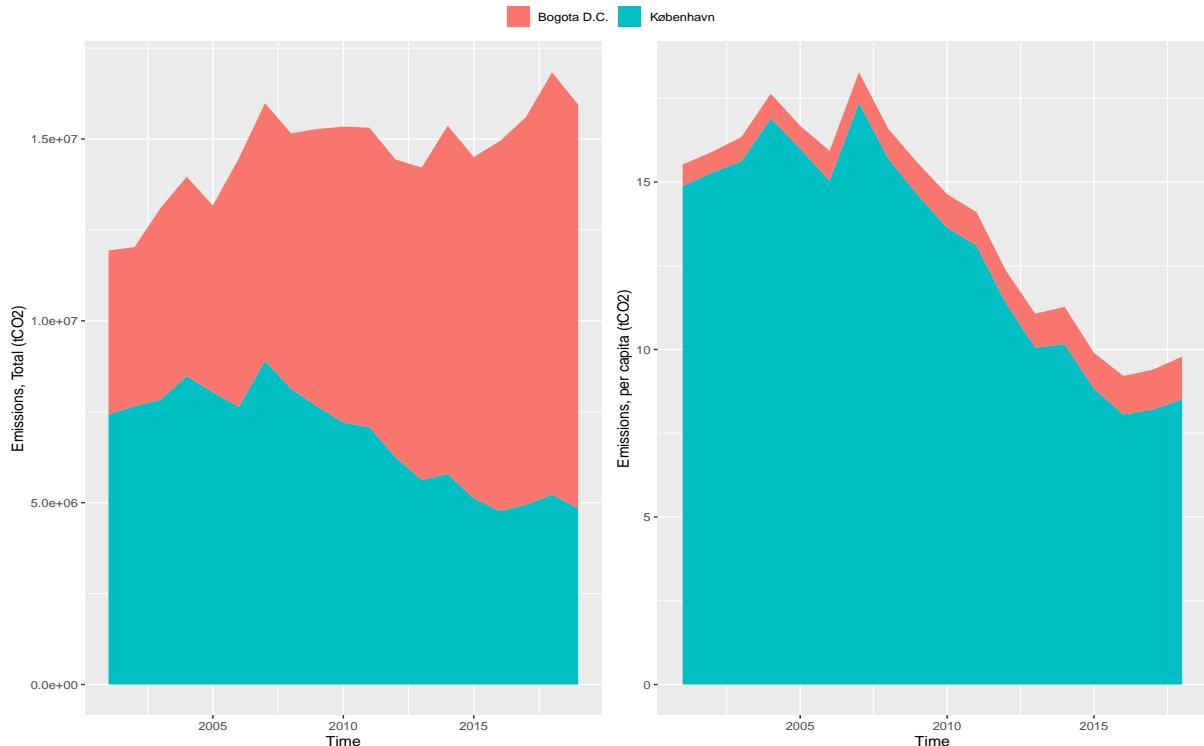

Figure 4-7: *Emission profiles for both the cases with temporal coverage from 2001-2019*

Fig. 4-8 shows the comparison of the two cases based on the independent variables of the statistical analysis. Bogotá has a relatively higher population, GDP and higher jurisdictional power where, Copenhagen is more densely populated with higher GDP per capita and interestingly, higher annual cooling and heating degree days. The most significant difference between the two has been the Government Effectiveness where Bogotá performs poorly with a negative rating owing to their poor forecasting and corruption of public officials [144]. Copenhagen lies under the Innovator city and Bogotá is part of the Megacity network under their respective C40 membership category and is also a member of the steering committee. Also, the focus of climate strategies differ for both cases, as the main focus of the Copenhagen CAP is on the emissions buildings and for Bogotá, it is on transportation. The list of mitigation actions reported by cities in 2020 is shown in Appendix C.2. The difference is evident in terms of the magnitude of the plans between the two cases. Copenhagen lists that 45% of all the reported actions in 2020 are already in the implementation stage while Bogotá has no plans or projects in implementation [145], given the municipality has just finished the CAP.

The case comparison also represents a pretext between the North-South divide which not only differs on the socio-economic indicators but also in terms of scientific indicators. Generally, the global north incorporates North America, Western Europe, some countries in East Asia, while the global south is seen as being comprised of Africa, Latin America and other developing countries in Asia and the Middle East. C40 initiative focuses more on the global south cities to accelerate the gap between the two and not only create climate equity, but also promote resilience and co-benefits in the region [Interview, B.6]. This is accredited to the fact that global north cities already have better knowledge management and experience in climate change issues as well as the resources to deliver on the promises. In the same context, the support from C40 in the global north is a relatively light touch, although the Lord Mayor of Copenhagen, Frank Jensen appears to be using the network to showcase Copenhagen's position as the "green leader" [146] and also, possibly attract industries and investors to engage in Danish green business. In Copenhagen, the primary data reflected on the fact that C40 membership is held by the financial administration and have mostly focused more on bureaucracy and financing. Besides the headquarters in London, C40 opened an office in Copenhagen to bring together international partners and Danish cities together, and also to draw on knowledge from Copenhagen. Bogotá was actually one of the two cities that received support from the C40 Cities Finance Facility (CFF) to implement their sustainable urban mobility plans. CFF in partnership with the Inter-American Development Bank and the World Resources Institute has supported Bogotá in their long-standing cycling infrastructure project 'Medino Milenio Bikeway', which is a 25-km-long cycle highway project connecting citizens from all walks of life and providing a more sustainable, accessible and resilient public transport system which will commence on 2021. The support from CFF was overarching in ways, where they provided the technical support, both funding and financing and coordination with the key stakeholders.

4.4   Results

This section provides the results of the cross-case analysis using my research framework. The analysis and interpretation of data were iterative and for clarity, some of the statements were clarified again either through phone or email, to ensure the trustworthiness of my findings and
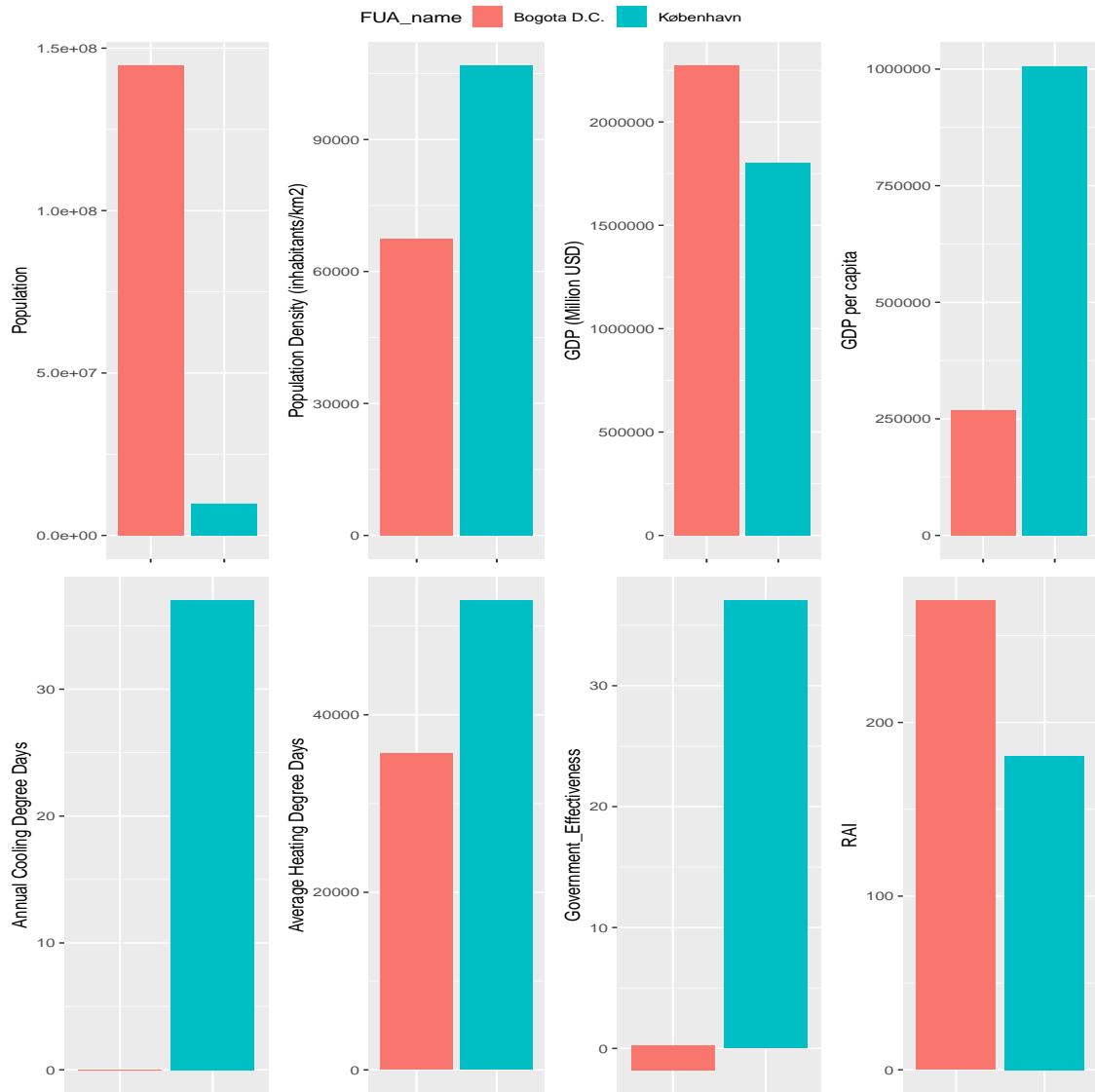
Figure 4-8: *Case comparison on different co-variates in my data frame*

prevent any misapprehension. Due to limited time and resources, little nuances of the climate work both from the municipality and C40 could not be established, although, the results account for the overarching role of C40 and its intervention along with different indicators of the analytical framework. I want to leave the reader a reminder that interviews transcripts can be found in the Appendix B. Some interviewees didn't agree for the transcriptions to be saved for future research nor to be put into this thesis, therefore complying with my ethical obligations, those transcripts have been left out of this report. The results of the comparison based on the research framework is shown in Table 4-2 below.

Table 4-2: Results of the cross case analysis based on the integrated research framework

	Copenhagen	**Bogotá**
C40 membership	Innovator city	Megacity
City urban type	Large metropolitan area	Metropolitan area
Vulnerable to climate change	Medium	High
Ambition	++	++
Indicator: alignment with Paris Agreement	Membership requirement	Membership requirement
Intervention: C40 imposes the 'Leadership standards' on its members to align the CAP with the Paris Agreement.		
Input	+/−	+
Indicator: Existence of GHG inventory	Membership requirement	Membership requirement
Indicator: Financial resources	Substantial budget allocated, no financing required from C40	Limited capacity financed; partially from CFF and some from the national government
Indicator: Adequate Human resources	Sufficient human personnel available and a C40 office	Limited staff within the municipality, although C40 provides dedicated personnel support
Indicator: Regulatory authority	High internal knowledge and expertise; C40 showcases and make best practises	Some internal knowledge but limited experience; both direct and indirect support from C40
Intervention: C40 require its members to report their emissions according to the GPC methodology and help cities in obtaining necessary financing through CFF. C40 also provides city advisors, network heads and regional directors at the direct disposable of the Mayor's. C40 also provides technical assistance through webinars, workshops and calls.		
Throughput	+/−	+
Indicator: "Political will" to act	Stable and sound	Currently very committed but conflicting history
Indicator: Commitment (by staff)	High commitment; being part of C40 improves motivation	Commitment varies; membership boosts motivation of the staff

Indicator: Inter-department coordination	Sufficiently established coordination prior to joining C40	Sufficiently established coordination; C40 engagement was crucial
Indicator: Knowledge management	Strong knowledge base; C40 highlights best practises	Some, but mostly outsourced; C40 provides assistance with partners from various consutlancies
Indicator: Monitoring and Evaluation	Present. Multi-year with feed back loop to policy	Absent

Intervention: It can be argued that C40 have a strong influence on the throughput from its activities within the network which affects the motivation for staff and also the networking possibilities provided from C40 allows cities to share and learn from each other. Moreover, lobbying at the national level ensure cities get sufficient support and finances for their climate action plans.

Output	— —	—
Indicator: Policy instruments	Wide set of instruments	Limited set of instruments
Indicator: Municipal governing typology	Collaborating	Collaborating/ Providing

Intervention: There is strong evidence on the relationship between C40 membership and output. C40 membership supports the adoption of policy instruments through the exchange of best practices within the network. Although, in the case of Copenhagen, no clear case was found where membership helped in the adoption of policy instruments, although, C40 constantly draws out best practises from Copenhagen. In Bogota, collaboration with different members within and beyond Latin America helped to promote the adoption of hybrid bus transit system.

Influence from higher government levels	+	+
Indicator: Policy linkage between national and local	Rarely misalignment	It has improved over the years
Indicator: Presence of support schemes	Both national and provincial government provide subsidies	Fluctuating but has increased from the base year 2010

Intervention: C40 is known for lobbying local government climate interests and also, inform members through the CAP framework to ensure alignment of the plans with the institutions and legal framework. C40 also has a coalition with UN and other TMNs under the Compact of Mayor which helps in increasing cities profile as a critical element to climate change.

Major external events		
Indicator: Geo-politics events	N/A	N/A
Indicator: Geo-physical events	COVID-19	COVID-19
Indicator: Economic crisis	2008	2008
Intervention: No relation with C40		

Implementation	–	–
Indicator: Implementation of projects	Half of the plans are in implementation stage	No plans implemented; Half of the plans are still in scoping phase
Indicator: Size and intensity of total mitigation projects	Comprehensive	Comprehensive but limited actions
Intervention: When it comes to implementation, it falls directly under the jurisdiction of the municipality and no direct relation can be established with the network membership		
Outcome	–	–
Indicator: Direct effect: change in emissions	Decreased emissions; relation with C40 not found	Increased emissions; no direct relation with C40
Indicator: Indirect effect: climate co-benefits	Green economy; Ecosystem preservation	Setting higher targets; Improved air quality
Intervention: It remains hard to establish if C40 membership can be associated with increase/ decrease of emissions, however the plans of cities entails percieved co-benefits from their actions.		

4.4.1 Increasing Ambition

C40's reach and influence continue to grow as C40 cities position themselves as the "pioneers" or "new climate leaders" against the climate change, as they stitch together the narrative often followed by the infamous quote from Mike Bloomberg "while nations talk; cities act" [147, 75]. C40 represents the climate leadership rising from the city-level, making Mayor's important individual actors who have the potential to fulfil the void created from the national incompetence [26]. It is necessary to acknowledge that C40 is not only a network of cities, it is also the network of most influential Mayors which makes it from a research standpoint, necessary to analyse the motives for participation and actual impact on the ambition of its member cities.

As stipulated in C40's leadership standards, signatories are required to commit to GHG reduction and formulate climate action plans in accord with the Paris agreement and further develop concrete initiatives to achieve those targets and sharing the knowledge and best practices with other cities in the network. In theory, the membership constraints or requirements help cities in raising their ambitions by aligning the targets according to the 1.5°C target, especially for cities in the global south. Hence, causality can be assumed between the network membership and the ambition of cities. Copenhagen CAP has already been approved and Bogotá just finished its CAP and is waiting for approval from C40. Moreover, participation of Latin cities in TMNs such as C40, ICLEI was central to put the climate agenda on the debate within the municipal halls all over Latin America. It was also brought up in the interviews that global north cities join climate network like C40, to maintain their climate ambitions and also, lobbying their interests on the national level, owing to their political leverage. In the case of Copenhagen, which is one big city in a small country and does not necessarily have other municipalities to compare or develop things with, therefore to avoid the 'big-fish-little-pond' effect, Lord Mayor was interested in joining C40. On the other hand, Bogotá has been a C40

member since 2005, and the reasons for participation has been due to political diplomacy and technical assistance. The political aspect of C40 was highlighted in the interviews which have been a trademark attribute of the network

It is safe to say that membership obligations from C40 have helped its signatories in either maintaining or increasing their ambition, although, the reasons for participation may differ significantly for the cities. It is too simplistic to say that the motivation behind joining the network is either for symbolic reasons or social-logical reasoning, as it may differ among the staff members and it has also been evident from the history that the motivation behind the participation may change over time. For instance, in Latin America some of these Mayors majorly see C40 as a platform, to promote and advertise themselves, as all these Mayors, wants to be the President, which sadly has been the case for both past and present. On the other hand, there are also politicians and city staff, who feel deeply inspired by the initiatives such as C40 Cities, but increasing the ambitions of city plans is only the first leg, the extent to which these are effective remains difficult to measure.

4.4.2 Bankrolling input

One of the key selling points of the C40 Cities network is their legitimate financial backing through collaboration and partnerships with philanthropies, banks, private stakeholders, etc. C40 does not hold any membership fees against its signatories and shows the significant influence on the input capacities of the municipality. The support varies in shape and forms for its different members, for instance, the C40 representative highlighted the fact that C40 put more emphasis on the global south cities and the support for the global north is a bit more superficial. It is also evident from the qualitative analysis, that the C40 intervention was more prominent in Bogotá than in Copenhagen. The rationale behind this as the funding is majorly ODA (Official Development Assistance) funding which focuses on global south cities [148] and thereafter, C40 develops regional programs for instance in China, Latin America, etc., with direct support from a group of cities to cities. This is achieved through the CFF, which facilitates financing for climate change mitigation in the developing and emerging cities in providing sustainable and carbon-neutral climate action projects [83]. The support from CFF is in the form of technical assistance, capacity development, and access to sectoral experts to facilitate enough cooperation within the city. Also, cities in the global north do not require a lot of assistance as they already have experience in developing climate action plans and measuring emissions, for example, cities such as Copenhagen, Stockholm, Amsterdam, etc. are internationally recognised climate action leaders. One of the misconceptions that were debunked from the interviews was that the C40 network did not have any role to play in formulating the Climate Action Plans for Copenhagen. The Climate Action planning is done by the Technical and Environmental Administration, whereas C40 liaises with the Financial administration dealing with business and political interests of the municipality, although they use technical outputs provided, they do not have any direct engagement with the plans. In Bogotá, the technical assistance from C40 has been major in the development of the CAP as part of the Deadline 2020 declaration [31]. The municipality claims that recent CAP is the most inclusive and transparent plan which was possible from the expert support provided by C40 through connecting with peer cities such as Barcelona, Buenos Aires, liaising with external agencies such as WHO, German academic exchange services, etc. and filling out the technical gaps through dedicated on the ground assistance directly to the municipality.

The network also recognises itself as a more data-oriented network rather than goal-oriented and aid cities in calculating and reporting their emissions according to the GPC methodolgy and require its members to update the inventory every two or maximum four years. Moreover, C40 works in city priorities, for instance, if the priority of the Mayor is economic recovery post-pandemic, then C40 engages fluidly to ensure the climate agenda does not get neglected. For example, C40 assist in developing resilient post-COVID mass transit system or lobbying for green stimulus on national and regional governments. C40 also indulges in showcasing activities to support the actions of Mayors and also has an award system to provide global legitimate recognition to cities [33]. Although, it has been established that the support differs within the network and is prioritised based on the context and position of cities against climate change, for instance, almost all of the global south cities have a dedicated city advisor who helps cities in different stages of climate action planning and also coordinates between different members (horizontally) and at the regional and national level (vertically) for knowledge exchange. The presence of a dedicated C40 official also legitimises the perceived image of the organisation among the citizens and other stakeholders which can be critical in establishing a dialogue between essential stakeholders both internally and externally. This was key in the case of Bogotá and other Latin American cities, where C40 played a key role in orchestrating the dialogue with the Chinese electric vehicle giant BYD in the pursuit of cutting down emissions from the transport sector which is the major source of emissions in Bogotá.

4.4.3 Importance in throughput

The role of dedicated personnel staff provided by C40 is key in ensuring and maintaining climate change on local political and policy agendas. The roles, responsibilities and expertise of appointed C40 support differ such as, city advisors may emphasize the capacity building for the municipalities and regional director may be responsible for ensuring the climate agenda remains important in the events of changing Mayoral power or lobbying to the national government. Once the climate plans are finished at the municipal level and approved politically, C40 verifies the plans to ensure the plans are ambitious, aligns with the Paris Agreement and validity of the projects or actions listed in the CAP. Although, it was brought up in the interviews that the monitoring system is something C40 is currently working at for all its cities, although Copenhagen already has a robust monitoring and evaluation framework in place to evaluate the climate actions.

The expert support provided by C40 acts as the "local catalyst" [6] with not only technical competencies but also managing networks, niche managing and acting as the 'policy entrepreneur(s)' to keep climate issues on political and policy agendas [6]. It was strikingly highlighted in all the interviews on the agility of C40 to obtain political leverage for the municipalities in terms of agenda-setting, obtaining funding or policy-making. For example, in Copenhagen, the engagement with the C40 has sort of improved the city's stance in the political dynamics to lobby and protect the city-level interest and also, influence the decision making at the national level. For instance, Copenhagen was able to cooperate with the national government to change the legislation regarding the water fees in their endeavour to finance their adaptive measure plans in water management. Another important factor to highlight is that global TMNs such as C40 provides a platform to create synergy's between its different members and ensuring collective learning through knowledge and best practises [149], for example, Copenhagen works very closely with Chinese cities on building energy efficiency

[150]. According to the municipality of Bogotá, the involvement of C40 has been massive and the functionality of the network varies from lobbying interests at the national level, educating staff at the municipal level and ensuring coordination among different departments in the municipality.

4.4.4 Output from experimentation

As highlighted by Bulkeley and Broto in their renowned publication [151], arguing that 'climate change experiments' are the potential approach adopted by the climate networks. The idea is to generate relevant material from small-scale projects, policies or plans subjected to real-life constraints. Therefore, the network provides a space for collaboration, policy learning and socializing transcending the boundaries of regional and national government [67]. Similarly, C40 is known for designing and implementation of various pilot schemes and projects for the diffusion of government-related knowledge within the network [68]. C40 has listed 100 'Good Practice' guides covering a range of climate actions based on different sectoral themes, made publicly available for cities to have better economic, social and environmental outcomes outlining results, critical benefits and when to adopt a similar approach [143]. However, it is to be noted that cities governing typologies vary within the network based on multiple factors such as political history, geography, cultural context, etc. Moreover, cities can use different levers such as projects, policies, incentives, etc. depending on their governing typology. Both the mitigation projects for both the cases and the different governance typology formulated by C40 can be found in Appendix C.1 and Appendix C.2 respectively.

The results from the analysis show evidence in both Copenhagen and Bogotá on collaboration, leveraging information and adoption of policy actions or schemes from the network membership. Bogotá and other 24 cities within the network joined the 'Clean Bus Declaration' providing incentive for the bus manufacturers to adopt clean technologies in the pursuit of curbing emissions from the transport sector, specifically in Latin America [152]. Before this declaration, Bogotá in partnership with C40 tested the fleet renewal with hybrid and electric buses [152]. For Copenhagen, it was found that Copenhagen joined forces with New York to develop more comprehensive resilience strategies and learning from the experience of each other. New York City's Cloudburst Resilience Planning Study [153] is based on Copenhagen's approach for a cloudburst to manage extreme rain events.

4.4.5 Barriers to implementation

When it comes to implementation, it can be argued that the C40 network does not have any direct relation with the delivery of a climate action plan. Also, the cases analysed reflected strong differences in terms of status and intensity of the respective mitigation plans. For example, Copenhagen already has implemented 45% of their latest reported plans, while Bogotá has been struggling to get the financing. The final climate action plan of the cities highlights the potential barriers in the implementation of their plans using the C40's CAP framework, however, there is not much direct impact C40 can have when it comes to implementation. The support provided from C40 to its signatories in the development of climate action plans, specifically for global south cities is through identifying potential financing for their projects and also, the technical support in doing their inventories. Although, the implementation of

the plans remain restricted depending on the financial capacity, limited jurisdiction, lack of public support and influence from higher government levels. It has hardly ever been the case, where institutional dynamics does not play a role as effective implementation of policies depends on good governance, which further depends on institutions in place at various levels and the resource availability [154]. Despite the best of intentions, conflicting priorities, such incongruence of environmental targets with the economic advancement can cause a delay in the implementation of the projects [155]. For example, the Danish government proposed to lower the registration tax on cars from 180% to 100%, to shift the buyers from EVs to conventional fossil fuel cars, an initiative aimed to increase car ownership and expand the labour force [156]. The rationale behind this was clearly against the climate-neutral target for 2025, which distrusts the budget for climate mitigation projects, and highlights the importance of support and incentive from the national government. In the context of Bogotá, lack of public support and internal political rivalries, have been identified as additional factors besides the lack of incentive for change. For instance, when Peñalosa was elected as the Mayor in 2016, although he was in the favour of climate agenda, he stopped the international activities and initiatives which were particularly set up by the previous Mayor Petro, just to display his hegemony on the state [Interview, B.3]. Another challenge that was highlighted was the lack of incentive for citizens or private stakeholders to adopt the sustainable measure, which also traces back to the national government to some extent. For example, the main focus on mitigation for Bogotá has been the transportation sector, and one of the main barriers in this sector is to reduce the emission from freight which is regulated by the private sector. The small truck drivers may not have the finances or simply do not have the right incentive to switch to sustainable options, therefore private sector collaboration remains an existing challenge in the cities. The same story unfolds in Copenhagen, where trucks coming from Sweden, Germany, etc. may not comply with the regional regulations of the country. The national government linkage can enable cities to showcase the benefits of membership as a measure of implemented actions.

C40 announced the 'Deadline 2020' program where all the signatories were expected to have inclusive climate action plans in alignment with SDGs, national targets and Paris agreements. From the interviews, C40 representatives mentioned that the implementation of these plans moving forward is something C40 are working on and they will provide aid and support wherever they see cities may lag from their targets. Copenhagen and other global north cities have been pretty evident climate action planning, however, it would be interesting to see in Bogotá and other global south cities, if they can deliver on their promises from 2020, given the ongoing pandemic, slow vaccination rate and rising poverty. The status quo of the Bogotá municipality reported scarce resources both in terms of finances and human capacity, which can delay the implementation, as the current focus is on the 'green recovery' and ensuring the city has enough vaccination at its disposal. The shift in the priorities of the cities due to pandemic is a major disruption in climate action. The role of C40 as a TMN is limited when it comes to the implementation, however, the regional directors and also, other staff from C40, works strongly on making evidence-based cases against climate change through research and diplomacy to ensure climate agenda remains the priority of Mayors and ensuring partnerships from financial institutions, but as mentioned, the implementation is very context-dependent, and remains a multivariate problem with both exogenous and endogenous factors [155].

4.4.6   Tracing outcome

The direct outcome from C40's membership in this research is explained as an increase/decrease in CO_2 emissions. It is difficult to assume a direct relationship with the outcome as it highly depends on the implementation of intended plans which C40 have very little influence on. Copenhagen owing to its robust capacity and national government's commitment to energy transition, have been able to achieve significant reductions and is on track with its carbon-neutral plan for 2025. On the contrary, Bogotá emissions have increased steadily owing to the increase in population and industrial activity. However, it remains problematic to establish the causality of the progress or falling behind on the targets, more so in defining how "impactful" the membership from C40 is, given that cities participate in various networks and the limited influence of these networks on delivery. This also questions the engagement from municipality staff, as member cities tend to become passive in terms of participation in these networks and limited availability of resources for climate-related work. In the context of Copenhagen, C40 has majorly showcased Copenhagen as a success story, as a front runner in action against climate change and developing a business case of green jobs liaising with local sustainability and energy consultancies such as Ramboll. On the ground, C40 did not have anything to do with framing climate actions, and as a matter of fact, the mayor of technical administration used to be highly critical of C40 due to political conflict because the financial administration was led by a mayor from the social democratic party whereas the mayor of the technical and environmental administration was led by "Enhedslisten" – a party more to the left in Danish politics and thus more critical of the green growth narrative [Interview, B.2]. The average annual % change in per capita emissions has been stagnant for Bogotá and even if the progress in terms of commitment and planning has been established through C40 membership. However, in terms of direct outcome in climate mitigation, the transition is still quite a slow process considering Bogotá has been in the C40 network since its inception.

Heikkinen et al. [157] in their research on C40, highlighted that C40 mostly supports incremental changes and very rarely, transformational changes, which in the context of climate mitigation would be the highest degree of change in city's governance, for example, cities adopting energy-saving technologies or changing citizens behaviour in adopting the sustainable lifestyle, etc. These changes take time to materialise especially in the context of global south cities, with complex institutional dynamics and hardly any background in climate action and any support or incentive to take action regarding climate change. For instance, Bogotá not only requires drastic changes in its transportation sector but also change in the climate institutions and behavioural change from its citizens, which of course takes time and given the socio-economic conditions and the ongoing pandemic, makes it very difficult for the Mayor to prioritise climate change over other societal concerns. Another thing to take into account is most of the plans will be finished by 2020, and currently, only 36 out of 169 CAP of registered cities are compatible with the Paris agreement [158]. Therefore, urgency towards climate action and more importantly, implementation would be critical to be evaluated in this decade, when the city investments will come to full maturity.

Chapter 5

Discusssion

5.1 Quantitative Analysis

Analyzing the results of the statistical analysis and comparing it with the broader literature, certain insights can be drawn. First, it is evident that C40 membership had no role to play in the reduction of CO_2 emissions in the OECD cities. The cities are reacting against climate change by engaging in the TMNs, and try to present themselves in a positive light, although the implementation and effectiveness of promised strategies remain contentious [159]. This also blurs the line on their role in the implementation of climate action plans by municipalities. Although, study performed by Steffen et al. [89] showed a positive impact of C40 membership on utility-scale solar PV investment, the positive effect was most dominant for the cities in China where only Tokyo stood out as a non-Chinese city in the top 30 and shows a serious lag between OECD countries and China. While there is no denying the fact the joining these network members has certain tangible benefits in terms of policy learning, coordination and credit claiming; the literature on collective actions still suggest that simply joining a network or group does not necessarily lead to changes in behaviour which could further be translated into measurable outcomes [160]. Heikkinen et al. [157] also highlighted that "C40, promote themselves as venues for mutual learning and member cities claim that some policy learning does occur, but this learning flows in an unequal manner within the network", which makes it unclear how these benefits are distributed, what precisely is derived from these benefits and how profound these solutions are in terms of the change they envisage. Although, climate networks such as C40, EUCoM have helped cities to have more ambitious climate action plans, Khan & Sovacool [88] showed in their research that the higher aspiration does not necessarily reflect upon the motivation for cities to take action which is dependent on various political factors at both local and national level [51].

Second, from the modelling perspective, the regression analysis presented in this study entails the same level of sophistication compared to previous econometric studies on municipal emissions (e.g. [36, 161, 162]). The socio-economic factors such as % change in population had positively influenced the increase in emissions at the municipal level, although % change in

GDP per capita had no significant impact when the country dummy was included in the analysis. Interestingly, the analysis showed that the average cooling degree days were relatively more significant than heating degree days, even though the overall impact is small on the emissions. This can be explained by the rising temperature and demand for cooling growing rapidly, with a threefold expansion since the 1990s [163]. The need for air conditioning for both residential and commercial significantly affects the electricity demand and is expected to drive peak demand especially in hot countries (e.g USA, Mexico, Colombia, etc.). The results also provide new evidence on the importance of governing capacity of municipalities as cities with better preconditions for governing capacity have significantly reduced emissions, which ought to be considered in budgeting, formulation and implementation of local climate action plans. The study also showed that a higher degree of decentralisation had resulted in lower emissions for cities, therefore it is important for cities to have inter and intra-municipal cooperation to improve the efficacy of their climate actions.

Third, the impact of determinant differs significantly in different city urban areas, where results are in contrast to some of the previous literature [36], where small urban areas displayed the highest decrease in emission per capita, where reductions were mostly accredited to high government effectiveness of the small municipalities. Also, only municipalities of large metropolitan areas were able to show a decrease in their emissions with a % increase in their GDP per capita. It can be implied that large metropolitan areas resource consumption and availability differ significantly as compared to other urban types, although this is not entirely enough to have even reductions throughout.

5.2   Qualitative Analysis

This section summarises the findings from qualitative case studies and relates them with the existing broader literature of urban studies, sustainable transition studies and environmental science. The support from network membership differs for global north and south. It is difficult to single out the effect of C40 purely as it differs between the signatories. However, from the research framework, C40 has a strong influence on increasing the ambition and capacity building for cities, besides that C40 cannot directly influence any decision-making in terms of implementation of plans. Although, joining TMN and committing to ambitious targets does not necessarily translate into emission reduction even if the reductions have been occurring thus far. The reason for joining the network is mostly because of C40's strong political engagement and environmental diplomacy. Although, it is too simplistic to say that reason for participating is purely for symbolic reasons or socio-logical reasoning. The motivation can differ within the municipality and is often subjected to change with time. The financial situation of the municipalities is one of the biggest factors impacting the city-level emissions. The budget constraints cripples the municipality in investments even if they have sufficient authority in the respective sector. Particularly after COVID-19, which has diverted attention from the climate agenda resulting in the re-allocation of budget towards support packages and vaccines. The reach of C40's influence in enabling climate action is very limited when it comes to the actual implementation. Prior to the Deadline 2020 declaration, the C40 network never obliged its signatories to commit to local climate strategy and focused more on the acceleration of learning processes through professional expertise and indirect funding [32]. Lack of enforcement and lenient participation can result in cities being passive in the network,

leading to limited success [164] and creating "leaders" and "laggards" in the network. I think C40 realised that and made adjustments by formulating the new leadership standards for all its signatories to have same the level of ambition and also, by providing personnel support, specifically in the global south cities to shorten the gap. In the same context, Lee [165] argued that signatories within the network do not reap the same benefits which is evident as the network is more oriented towards the megacities and is largely dominated by cities like New York and London [28].

One of the key success factors for C40 is the strong political aspect of the network. The government structure and political context of a city play a significant role when it comes to concrete actions which can also be traced back to the regression model, where the country dummy showed the highest increase in the explanatory power of the model. The procurement of finances due to complex legal institutions and risk regarding changes in political support are the key challenges for Bogotá in implementing the CAP. Even in the case of Copenhagen, the motivation to be a part of the network majorly comes from the Financial administration to use C40 cities international network of some of the leading cities against climate change in order to dismiss the 'Big-fish-little-pond' effect in Denmark.

Guo et al. [166] showed a negative correlation between environmental diplomacy and emissions in the short-run for developing countries. This has not been evident in the case of Bogotá, where emissions have increased, this implies the participation intensity may not be the same, considering Bogotá is part of the network since its inception. This was also confirmed in the interview that Bogotá has been more engaged with C40, since the appointment of Mayor López. Hence, the implementation has been lacking owing to the multiple conditions such as the lower capacity of cities which hinders their participation [51], non-alignment of the national and municipal policies, etc. are some of the gaps where TMNs have very little influence. It can be argued that C40 has evolved from merely a knowledge sharing and learning network model to a high-profile network enabling cities to remain ambitious and resetting the climate narrative through building collaboration and coordination. The role of C40 in aiding the municipal climate work depends on various factors, such as the type of member, climate risks of the city, institutions in place, capacities of the municipality and also international reputation against climate change. The use of C40 membership by its signatory can be merely symbolic or comprehensive depending on their history with climate change, legal institutions in place and availability of resources.

The barriers in implementation are causing cities to unfulfilling their potential in terms of climate mitigation. The C40 can orchestrate cooperation among the relevant stakeholder to ensure the delivery but climate network is not a panacea cannot directly influence decision making yet or laws around it. In the context of Latin America, besides lack of input and throughput capacities, the political context for climate agenda has been a constant barrier causing disruption in the energy transition in that region. I suspect the same truth would unfold in other global south cities such as Accra, Jaipur, Santiago, etc. Hence, there is only so much TMNs can do, if cities do not have the support from the legislation and laws around climate change. C40 is already making tracks liaising with the national governments in Germany, UK and Denmark for grants and diplomacy to bridge the gap between north and south cities. I argue that the efficiency of C40 should be measure on closing the gap between the north-south emissions, rather just showcasing the champions in the global north region.

5.3   Triangulation and Validation of Results

One of the limitations of the mixed methods if not carefully designed and interpreted, is the validity and quality of the results. Hence, it is necessary to address the limitations of generalisability and transferability of the results and threats to validity. Both the quantitative and qualitative studies suggest that no relationship can be established between the C40 network membership and decrease in CO_2 emissions. Although, this result could have been achieved with individual studies as well, qualitative study aided in explaining the finding of the quantitative analysis. Moreover, this result is generalisable to all the OECD cities as the cities selected entailed sufficient variation ensuring the validity of the empirical relationship as shown in Appendix A-4. The internal validity of the statistical analysis is robust as the data were taken from trusted existing databases and the GIS emissions were found to be closely linked with the Scope 1 + Scope 2 emissions. Although, this cannot be said for sure as the ODIAC measuring methodology is quite different from the GPC methodology. The ODIAC uses spatial and carbon intensity data to measure the emissions at a 1 Km X 1 Km, while cities use scope base framework to measure emissions. Hence, the aggregation of GIS emissions may also entail Scope 3 emissions, which is evident in the difference between the absolute values of the databases. Regardless, the harmonised OECD shapefile for cities, ensures the CO_2 emission are accounted for within the city boundaries. Moreover, only the relative change in CO_2 emissions is used for the analysis which also diminishes any reliability issue. Concerning the qualitative analysis, more case studies are required to validate my findings. There can be a potential bias in taking interviews from C40 representatives. Although, the content was carefully interpreted and cross-validated to ensure clear evidence is provided in this research.

Besides the network membership, the triangulation also provides some meaningful insights. First, from the robustness checks, it was evident that RAI as a proxy for the degree of decentralisation was significant accounting for an annual decrease of 0.12% in CO_2 emissions. It can also be tracked back in the Danish context where the municipalities relish the assigned leadership and responsibilities at the local level resulting in better engagement of private stakeholders and citizens. [167]. The success of Copenhagen can be accredited to the commitment to the energy transition from Danish government, ambitious targets of the city and the ability to create synergy between public, private and citizens concerning energy consumption [168]. Although the analysis didn't aim at establishing the success or failure of the network, Copenhagen success has not much to do with C40 and the motivation lies mostly because of showcasing and maintaining their ambition. Second, the dummy for country variable explained the most variance in the data, implying the country level effects such as existing institutions, culture, political history, etc., all have a significant influence on city level emissions which was also evident in both Copenhagen and Bogotá. Interestingly, one of the drivers in Copenhagen's success was support from the Danish government while in Bogotá national institutions and shifts in political power have negatively affected the climate agenda at the municipalities. Third, GPD per capita was only significant in the Large Metropolitan Areas where a % increase in GDP per capita results in a reduction of almost 0.6 % in CO_2 emissions. The qualitative analysis also reflects the same where climate actions in Bogotá were strictly subjected to the resource availability within the municipality, although further evidence is required to substantiate this finding.

5.4 Limitations

Quantitative Analysis

First and foremost, there is a selection bias as only selected OECD countries and only a subset of OECD cities have reported sufficient evaluation data. I also make no claim to have gathered a representative sample of transnational municipal climate network initiatives in general. Therefore, the findings have inherent biases as most cities in the sample belong to the global north which is viewed as relatively more progressive on their climate action plans, decarbonisation strategies and participation in the climate networks. However, the represented data contains enough variation for the OECD cities and findings i.e, no relation of membership and CO_2 emissions hold for the entire OECD as shown in Appendix A-4. Besides the variable of interest (network membership), there might be other potential variables apart from specified as controls. For example, I could not find information on the joining year of the C40 members as this data has not been made public by the C40 organisation or data on the industry intensity of cities. However, any uncaptured differences between members and non-members would have been levelled out over the large sample size.

Second, the analysis only focuses on climate mitigation in terms of measurable reduction in CO_2 emissions from the C40 signatories. The measurable reductions can also be observed in GHG emissions or methane for instance, which may lead to different results. Also, TMNs differ quite a bit with respect to the stringency of quantitative commitments towards climate change mitigation [29], where C40, in particular, requires mitigation commitments in terms of 'climate action plans and also, not being among the stringent ones. Hence, change in CO_2 emissions is one way to measure impact from network membership, but the network membership may potentially come out significant with other measures for climate mitigation.

Third, the analysis does not take into account the absolute values, but the rather relative change in the CO_2 emissions which hampers the credibility of the findings. In addition, the analysis does not capture the dynamic nature of C40 and consider network membership as a discrete entity (coded as dummy variable 0 or 1). The activity of the members within the network is not accounted for, as cities can become or active or passive in the network and also the network is subjected to change with time.

Finally, measuring the impact of a C40 Cities membership on annual % change in CO_2 emissions should be regarded as the first approximation only. To the best of my knowledge, the combination of OECD database and geospatial information from ODIAC is the first assessment to evaluate the performance of cities, however, the limitation lies in comparing the emission inventories of the self-reported data from cities, as the methodology differs in accounting for emissions. Although, this does not affect the validity of the results as they have been mitigated from the geospatial data counter claims against the usability of GIS data may be contestable.

Qualitative Analysis

In my research design, qualitative analysis was used to explain the statistical finding using a cross-case analysis approach based on my integrated research framework. Regardless of the cautious selection of the two contextual cases, the readers should bear in mind that the

results of this analysis cannot be readily generalized to other signatories of C40 or the entire network, as the results may entail bias due to lack of case studies. By no means, this analysis is extensive and comprehensive due to limitations of resources and time constraints, ideally, more case studies would have aided in the validation of information.

Another thing to consider is that the sole focus is on the climate mitigation policies and the 'impact' of the climate network on other focus areas such as adaptation or resilience is out of the scope of this research. This analysis is an attempt to provide an understanding of the role of climate networks in the interplay of local climate action, the interviews provided deep insights on the subject.

5.5   Recommendations for future research

Before closing this research, I want to point to several unanswered research areas that need to be explored in future research, followed by recommendations on improving the research design to understand the role of TMNs and further validate my findings.

First and foremost, more dedicated research is needed to explore the barriers cities face in the implementation of the climate action plans and also if the presence of a network membership can be associated with implementation. With regard to the analytical framework, certain indicators of the framework can be individually studied such as ambition and output indicators. Some of the areas that can be explored in future research can be whether the motivation to be a part of an "elite" network leads to unrealistic ambitions reflecting poorer on cities or whether learning from experimentation benefits signatories within the network in the adoption of policies. Further, the current academic literature still does not capture the interplay and engagement of different stakeholders along with the TMNs and also the underlying mechanisms and causal relationships within the system. More research is needed to establish the nuances of this engagement, for instance, the motivation of private stakeholder to collaborate with C40 network, the distribution of benefits and accountability inter and intra-network and allocation of responsibility and finances are some of the areas calling for further research. Also, this study did not examine the 'impact' of network membership on climate adaptation. It could be the case that network membership is associated with the adaptation outcomes of the municipalities which can potentially be investigated in future research.

In terms of research design, the same analysis needs to be repeated some odd years down the line. The first reason is to measure the impact of CAP and updated policies as most of the C40 members finished the CAP in 2020. The empirical research can be extended with better inputs such as, more shapefiles beyond OECD cities, granular data on C40, longitudinal data set with temporal values of emissions etc., to have more robust analysis on the membership significance subjected to improvement in quality of city-level inventory. This would also act as better input for qualitative case study design. In terms of qualitative analysis, more cases studies are needed especially in the global south to understand the drivers and barriers for climate action. More extensive case studies would aid the unpacking of micro-foundations of the C40 organisation and validation of my results. The research design may also be altered to single out the effect of network membership through dedicated case studies between different characteristics of TMNs. A case was made by Giest Howlett [65] where local 'in-depth'

networks can supposedly be more successful relative to global networks like C40, CoM, etc. Hence, the hypothesis on 'homophily' can be tested in future research if the global climate networks such as C40 are less effective relative to local climate networks like Hinku network in Finland.

Chapter 6

Conclusion

This thesis is aimed at addressing the question of whether C40 membership has translated into measurable outcomes and unpack the micro-foundations of network support. The final chapter concludes the research by answering the research question, recommendations for future research and finally, the policy advice for the government (both municipal and national). The main research question is as follows:

> *"What is the impact of C40 cities network membership in selected OECD cities on climate mitigation?"*

To answer the main research question, two complementary approaches are adopted to evaluate the role of the C40 cities climate network. The implications of findings will aid cities, the national government and the C40 network to address the gaps to accelerate climate action and improve the knowledge equity within the network.

6.1 Answering the sub-questions

In this section, the answer to all the sub-questions is shortly summarised.

6.1.1 Sub-question 1: conceptualising C40

SQ1: What is C40 and what does its governance structure look like?

C40 is a global network of the world's most influential Mayors and cities which was initiated by cities and led by cities i.e *Directory Board* (President: Michael Bloomberg, representatives of Bloomberg Philanthropies, CIFF, Realdania, Clinton foundation, etc.) and *Steering* committee (15 mayors). C40 offers different membership based on the city profile and comprises of the most influential cities based on population, GDP or prior history on climate action. The governing body of the network decides who joins the network and asks no membership

fee for participation. In that regard, there is some kind of exclusivity attached to the network as the access is only limited to 'elite' cities which makes the case for investigation on the motivation to join such networks.

C40 cities network has been successful in creating a highly sophisticated multilateral collaborative cooperation incorporating national governments, philanthropic actors and international business corporations. C40 aims at delivering evidence-based solutions and promote knowledge exchange, innovative climate policy insights [76]. C40 cannot be explained as a static entity, it has a feedback loop in its delivery model which enables C40 to constantly innovate itself subjected to the needs of its members. C40 input can primarily be classified as a role in the orchestration of city plans, hence bypassing the traditional regime to fill various gaps at the local level, where national governments have failed to do so.

6.1.2   Sub-question 2: empirical evaluation of C40

SQ2: What are the measured impacts of C40 membership on climate mitigation?

The results from the empirical analysis in Chapter 3 reflected that C40 has no direct influence on the % change in emissions in the OECD region. Although, scholars have noted C40's ability to facilitate city engagement towards climate action as opposed to solely for symbolic membership [89, 58, 87], it remains controversial to say that C40 membership has no significance on its members. The biggest rise in the explanatory power of the model was seen after the country dummy was added. It can be argued that regional characteristics such as language, political context, deeply rooted cultural factors and attitude of citizens have serious effects when it comes to translation of climate action plans. The analysis also provides empirical evidence on the governance indicators impact, as cities with higher government effectiveness were able to reduce emissions by 2.2% per year. Furthermore, the higher degree of decentralisation within a country is associated with a decrease in emissions. It was also found that small urban areas have achieved more reductions per capita relative to other city categories, owing to their high government effectiveness. Another important implication from the study is that the GDP as a proxy for resource availability and consumption is significant in emission reductions in the Large metropolitan areas specifically.

6.1.3   Sub-question 3: qualitative analysis of C40

SQ3: How does C40 membership affect municipal climate work and aid in climate mitigation?

In Chapter 4, a cross-case analysis is presented between two C40 signatories, Copenhagen and Bogotá. Both cases present massive variation in terms of culture, geography, history with climate change, climate risks and socio-political system. Interestingly, the intervention of C40 was also significantly different on the account of global north-south pretext which was also evident in my analysis, where the influence of network membership was stronger in Bogotá. It was found that C40 specifically focuses on the global south cities for two specific reasons: i.) global north cities already have better capacities and resources to tackle climate change, ii.) Most of the finances are focused on assistance towards the global south. In the context of my research framework, C40 membership was found to have a strong influence on increasing or maintaining the ambition of cities. Second, C40's influence is limited to

the intra-municipal indicators of the framework, i.e. *input*, *throughput* and *output* clusters of climate action at the local level which is reflected through improved capacities, catalyzing the climate action and policy learning from experimentation. Third, C40 is also known for lobbying at international summits and encouraging mayors to take leadership roles in global climate change politics, hence indicating a casual influence on higher-level government. Both the cases have been showcased extensively by C40, resulting in an improved stance and global image which was quite important in the case of Copenhagen to drive the reform in national legislation in Denmark. The lack of influence on the implementation of plans by the network can be accounted for the delay in the mitigation action. The main barriers identified in the cases are mainly alignment with national interests, financing, shift in political power and engagement of private sector and citizens. The inability of C40 membership to directly influence the intended climate action also contradicts the hypothesis of a direct relationship between *outcome* i.e., change in emissions and network membership. However, *outcome* can also be measured in terms of tangible co-benefits from the memberships which are beyond the scope of my analysis and calls for separate dedicated research.

6.2   Answer to the main research question

"What is the impact of C40 cities network membership in selected OECD cities on climate mitigation?"

To summarise, it remains difficult to establish the causality of this question. Both qualitative and quantitative findings suggest no significant direct relation with the membership on reducing CO_2 emissions for OECD cities in the period of 2001-2019. The cross-case analysis provides evidence that C40 intervention is more prominent in the global south cities. There is also evidence suggesting the network has "leaders" and "laggards" in terms of climate mitigation due to path dependency and the efficacy of C40 lies in bridging this gap. However, the reach of C40 is limited and the lack of translation of robustness to implementation from cities remains difficult for C40 to intervene. I argue that cities inability to procure finances, weak national legislation, corruption and political priorities hinders their participation in the network and thus, stagnating their progress on climate mitigation.

Even though support from C40 is fluid and relies on the priority of municipalities, the role of C40 can be generalised as enforcing soft governance tools to increase the ambition of its members, collecting and publishing data, etc., foster learning within the network, support mayors in maintaining the climate agenda within the institutional framework and provide tailored made support to its signatories ranging from building capacities to lobbying interests at the international summits. The biggest selling point for C40 is its political diplomacy and legitimized financial capacity for cities. However, it is too simplistic to say that the motivation for cities participating is either for symbolic reasons or socio-logical reasoning. The motivation differs significantly within the municipal departments and changes with time and political power. C40 support is catalytic and can bypass complex institutions to accelerate change, however, both qualitative and empirical study reflects that C40 network membership cannot be associated with mitigating emissions owing to the barriers for cities in the implementation of plans, which network membership do not have much influence yet. The potential of C40 is huge in this paradigm shift, and collective action from not only cities and national government

but also from private stakeholders is required to have any reasonable chance in making the 1.5°C target.

6.3 Reflection on societal relevance

The societal relevance is embedded in the implications of this research which primarily calls for collective action and cooperation to tackle climate change. Given, the emergence of TMNs and rising recognition of cities post COP21, it is evident that cities and TMNs will have an important role to play in this decade. The fluid nature of TMNs allows them to find knowledge gaps and aid assistance to enable cities against climate change. This research provides a transparent account on C40 enable cities on climate mitigation to establish a better understanding in the potential and future role of these transnational commitments. To further emphasize the societal significance of my findings, suggestions for relevant actors are summed up underneath.

National governments

- National government need to ensure sufficient finances and human personnel is provided to the municipalities, especially the Larger metropolitan areas.

- Linkage is necessary between the local and national government priorities and policies.

- Allowing TMNs to integrate within the system and capitalize on their capacity to play different roles within the dynamics such as 'consultants' , 'commitment brokers', etc., instead of an excluded entity lobbying for change.

- The national government can play a better role in the diffusion of 'best practises emerging from the transnational initiatives within the country to be adopted for other municipalities.

- Provide national fiscal stimulus to capitalize on the opportunity post-pandemic focusing on green recovery instead of supporting carbon-intensive business as usual activities.

- National government need to provide grants focusing on the most affected income households and businesses to ensure cash-flow within the city and directly to municipal projects through taxes.

Local governments

- Focus on improving city management including proper planning and delivery of climate action plans, financial analysis for the plans and also, risk assessment.

- Cities need to position themselves better for both direct funding (from the national government) and indirect funding (from banks and private institutions).

- Steady commitment to the targets and devising innovative solutions to deliver through proper utilisation of the services provided from climate networks.

- Municipalities in the global north can engage in crowdfunding for sustainability projects in the developing cities.

C40 Cities network

- Impose stringent institutions for members to commit and deliver to their targets.

- Showcases the benefits for collective action and support cities to engage and collaborate with various partners.

- Develop a robust monitoring and evaluation system for cities to keep track of progress and plans.

- Developing and improving emissions inventories for cities.

- Building a transparent relationship with its partners and members.

- Providing contextual support to cities especially in the global south.

6.4   Reflection on academic relevance

The scientific relevance of this research encompasses addressing the knowledge gap, methodology and recommendations for future research. This study contributes to the academia on the potential impact of non-state actors such as cities on climate mitigation. The novelty of the research arises by deploying a mixed-methods approach to single out the role of the C40 cities climate initiative. To the best of my knowledge, this study is a first attempt to combine GIS emission data with other city performance indicators for the evaluation of cities and to analyse the performance of a transnational network. This approach overcomes the traditional barriers of using self-reported emission data of cities, such as standardize methodology, different and missing baseline years are some of the areas which make the comparison and evaluation of cities difficult. Another contribution of this research is the synthesis of the qualitative analytical framework and its application to analyse the intervention from C40 membership. The research has limitations to it which have been highlighted in detail in the report, the different design elements of the research, provided a basic foundation in understanding the impact of TMNs and lay the ground for future research to be explored.

In hindsight, I think more time and resources could have nuanced the research output further, but nevertheless, this thesis lays the ground for future avenues to be explored by researchers. My advice for researchers who wish to use GIS emissions for their empirical study must carefully select the shapefiles for cities and understand the boundaries and what they represent. If not done correctly, it may result in over or under-estimation of emissions. Moreover, the GIS files can be imported in R or Python instead of QGIS to decrease the computational time three-fold. Another challenge experienced was in the case study, it is difficult to establish the interviews with municipal servants, especially in big municipalities. Liaising and conducting the interviews was more challenging than I anticipated, owing to the pandemic which makes on-ground research challenging than it should be. My advice for researchers who are doing research at the comfort of their homes is to establish contact early in their research process.

Bibliography

[1] "Climate Action Planning Framework," tech. rep., C40, New York, 2017.

[2] C40, "Connecting Cities to Deliver Climate Action,"

[3] J. W. Dash, "Climate Action in Megacities (CAM 3.0)," no. December, pp. 97–98, 2015.

[4] D.-D. Lab, "ClimActor: Data cleaning workflow for climate actor data," 2021.

[5] T. N. Hale, S. Chan, A. Hsu, A. Clapper, C. Elliott, P. Faria, T. Kuramochi, S. McDaniel, M. Morgado, M. Roelfsema, M. Santaella, N. Singh, I. Tout, C. Weber, A. Weinfurter, and O. Widerberg, "Sub- and non-state climate action: a framework to assess progress, implementation and impact," *Climate Policy*, vol. 0, no. 0, pp. 1–15, 2020.

[6] T. Hoppe, A. van der Vegt, and P. Stegmaier, "Presenting a Framework to Analyze Local Climate Policy and Action in Small and Medium-Sized Cities," *Sustainability*, vol. 8, p. 847, 8 2016.

[7] "C40 Cities: The Power to Act," tech. rep., Arup.

[8] T. Damsø, T. Kjær, and T. B. Christensen, "Implementation of local climate action plans: Copenhagen – Towards a carbon-neutral capital," *Journal of Cleaner Production*, vol. 167, pp. 406–415, 11 2017.

[9] "Functional urban areas by country - OECD."

[10] "Powering Climate Action: Cities as Global Changemakers Executive Summary,"

[11] F. C. Aguiar, J. Bentz, J. M. N. Silva, F. Duarte, G. Penha-lopes, A. L. Fonseca, and R. Swart, "Adaptation to climate change at local level in Europe : An overview," *Environmental Science and Policy*, vol. 86, no. September 2017, pp. 38–63, 2018.

[12] S. Grafakos, G. Viero, D. Reckien, K. Trigg, V. Viguie, A. Sudmant, C. Graves, A. Foley, O. Heidrich, J. M. Mirailles, J. Carter, L. H. Chang, C. Nador, M. Liseri, L. Chelleri, H. Orru, K. Orru, R. Aelenei, A. Bilska, B. Pfeiffer, Q. Lepetit, J. M. Church,

M. Landauer, A. Gouldson, and R. Dawson, "Integration of mitigation and adaptation in urban climate change action plans in Europe: A systematic assessment," *Renewable and Sustainable Energy Reviews*, vol. 121, no. February 2019, p. 109623, 2020.

[13] J. Klein, M. Araos, A. Karimo, M. Heikkinen, T. Ylä-Anttila, and S. Juhola, "The role of the private sector and citizens in urban climate change adaptation: Evidence from a global assessment of large cities," *Global Environmental Change*, vol. 53, no. October, pp. 127–136, 2018.

[14] K. W. Abbott, "The Transnational Regime Complex for Climate Change," *Environment and Planning C: Government and Policy*, vol. 30, pp. 571–590, 8 2012.

[15] United Nations Environment Programme, *Emissions Gap Report 2019*. 2019.

[16] C. Göpfert, C. Wamsler, and W. Lang, "A framework for the joint institutionalization of climate change mitigation and adaptation in city administrations," *Mitigation and Adaptation Strategies for Global Change 2018 24:1*, vol. 24, pp. 1–21, 3 2018.

[17] R. J. Dawson, "Potential pitfalls on the transition to more sustainable cities and how they might be avoided," *http://dx.doi.org.tudelft.idm.oclc.org/10.4155/cmt.11.8*, vol. 2, pp. 175–188, 4 2014.

[18] V. Castán Broto and H. Bulkeley, "A survey of urban climate change experiments in 100 cities," *Global Environmental Change*, vol. 23, pp. 92–102, 2 2013.

[19] P. Kivimaa, M. Hildén, D. Huitema, A. Jordan, and J. Newig, "Experiments in climate governance – A systematic review of research on energy and built environment transitions," *Journal of Cleaner Production*, vol. 169, pp. 17–29, 12 2017.

[20] V. Palermo, P. Bertoldi, M. Apostoulu, A. Kona, and S. Rivas, "Assessment of climate change mitigation policies in 315 cities in the Covenant of Mayors initiative," *Sustainable Cities and Society*, vol. 60, no. April, p. 102258, 2020.

[21] P. Erickson, M. Lazarus, C. Chandler, and S. Schultz, "Technologies, policies and measures for GHG abatement at the urban scale," *Greenhouse Gas Measurement and Management*, vol. 3, pp. 37–54, 6 2013.

[22] U. Nations, D. of Economic, S. Affairs, and P. Division, "World Urbanization Prospects: The 2018 Revision," 2018.

[23] K. Gurney, P. Romero-Lankao, K. Seto, L. Hutyra, R. Duren, C. Kennedy, N. Grimm, J. Ehleringer, P. Marcotullio, S. Hughes, J. Feddema, and J. Sperling, "Climate change: Track urban emissions on a human scale," *Nature*, vol. 525, no. 7568, pp. 179–181, 2015.

[24] "UNFCCC: Paris agreement - Google Scholar."

[25] V. Castán Broto, "Urban Governance and the Politics of Climate change," *World Development*, vol. 93, pp. 1–15, 5 2017.

[26] H. Bulkeley and M. M. Betsill, "Environmental Politics Revisiting the urban politics of climate change," *Taylor & Francis*, vol. 22, no. 1, pp. 136–154, 2013.

[27] H. Bulkeley, L. Andonova, M. Betsill, and D. Compagnon, *Transnational climate change governance.* 2014.

[28] M. Acuto, *Global cities, governance and diplomacy: The urban link.* 2013.

[29] J. S. Bansard, P. H. Pattberg, and O. Widerberg, "Cities to the rescue ? Assessing the performance of transnational municipal networks in global climate governance," *International Environmental Agreements: Politics, Law and Economics*, vol. 17, no. 2, pp. 229–246, 2017.

[30] "Climate Action in Megacities: 40 cities 297 million residents 4,734 climate actions C40 Cities Baseline and Opportunities," tech. rep., 2011.

[31] "C40 : Deadline 2020."

[32] L. Hakelberg, "Governing Climate Change by Diffusion Transnational Municipal Networks as Catalysts of Policy Spread,"

[33] "Unlocking Climate Action in Megacities - C40 & Arup,"

[34] J. F. Green, "The strength of weakness: pseudo-clubs in the climate regime," *Climatic Change 2015 144:1*, vol. 144, pp. 41–52, 8 2015.

[35] C. Kennedy, S. Demoullin, and E. Mohareb, "Cities reducing their greenhouse gas emissions," *Energy Policy*, vol. 49, pp. 774–777.

[36] A. Hsu, J. Tan, Y. M. Ng, W. Toh, R. Vanda, and N. Goyal, "Performance determinants show European cities are delivering on climate mitigation," *Nature Climate Change*, vol. 10, pp. 1015–1022, 11 2020.

[37] S. Karhinen, J. Peltomaa, V. Riekkinen, and L. Saikku, "Impact of a climate network: The role of intermediaries in local level climate action," *Global Environmental Change*, vol. 67, p. 102225, 3 2021.

[38] U. D. Jogulu and J. Pansiri, "Mixed methods: A research design for management doctoral dissertations," *Management Research Review*, vol. 34, pp. 687–701, 5 2011.

[39] E. P. Jack and A. S. Raturi, "Lessons learned from methodological triangulation in management research," *Management Research News*, vol. 29, no. 6, pp. 345–357, 2006.

[40] E. J. Halcomb, "Mixed methods research: The issues beyond combining methods," *Journal of Advanced Nursing*, vol. 75, pp. 499–501, 3 2019.

[41] N. R. Draper and H. Smith, *Applied regression analysis*, vol. 326. John Wiley & Sons, 1 1998.

[42] T. Oda, S. Maksyutov, and R. J. Andres, "The Open-source Data Inventory for Anthropogenic CO2, version 2020 (ODIAC2020): A global monthly fossil fuel CO2 gridded emissions data product for tracer transport simulations and surface flux inversions," *Earth System Science Data*, vol. 10, pp. 87–107, 1 2018.

[43] C. Nangini, A. Peregon, P. Ciais, U. Weddige, F. Vogel, J. Wang, F. M. Bréon, S. Bachra, Y. Wang, K. Gurney, Y. Yamagata, K. Appleby, S. Telahoun, J. G. Canadell, A. Grübler, S. Dhakal, and F. Creutzig, "A global dataset of co2 emissions and ancillary data related to emissions for 343 cities," *Scientific Data*, vol. 6, pp. 1–29, 1 2019.

[44] M. M. Rittel, Horst W.J. & Webber, "Dilemmas in a general theory of planning," *Washington Quarterly*, vol. 15, no. 1, pp. 157–168, 1992.

[45] J. Seawright and J. Gerring, "Case Selection Techniques in Case Study Research A Menu of Qualitative and Quantitative Options," *Political Research Quarterly*, vol. 61, no. 2, pp. 294–308, 2008.

[46] "ATLAS.ti: The Qualitative Data Analysis & Research Software."

[47] T. Kuramochi, M. Roelfsema, A. Hsu, S. Lui, A. Weinfurter, S. Chan, T. Hale, A. Clapper, A. Chang, and N. Höhne, "Beyond national climate action: the impact of region, city, and business commitments on global greenhouse gas emissions," *Climate Policy*, vol. 20, no. 3, pp. 275–291, 2020.

[48] A. Sharifi, "Trade-offs and conflicts between urban climate change mitigation and adaptation measures: A literature review," 12 2020.

[49] M. Babiker, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield, "Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty," tech. rep., IPCC, 2017.

[50] T. Baycan-Levent, A. A. Gülümser Akgün, and S. Kundak, "Success Conditions for Urban Networks: Eurocities and Sister Cities," *European Planning Studies*, vol. 18, pp. 1187–1206, 8 2010.

[51] K. Kern and H. Bulkeley, "Cities, Europeanization and Multi-level Governance: Governing Climate Change through Transnational Municipal Networks*," tech. rep., 2009.

[52] N. J. Toly, "Transnational Municipal Networks in Climate Politics: From Global Governance to Global Politics," *Taylor & Francis*, vol. 5, no. 3, pp. 341–356, 2008.

[53] H. Fünfgeld, "Facilitating local climate change adaptation through transnational municipal networks," 2 2015.

[54] S. Mokhles and K. Davidson, "A framework for understanding the key drivers of cities' climate actions in city networks," *Urban Climate*, vol. 38, p. 100902, 7 2021.

[55] E. Smeds and M. Acuto, "Networking Cities after Paris: Weighing the Ambition of Urban Climate Change Experimentation," *Global Policy*, vol. 9, pp. 549–559, 11 2018.

[56] H. Bulkeley and K. Kern, "Local Government and the Governing of Climate Change in Germany and the UK," tech. rep.

[57] K. Blok, P. Hofheinz, and J. Kerkhoven, "How Efficiency Will Drive Growth, Create Jobs and Spread Wellbeing Throughout Society THE 2015 ENERGY PRODUCTIVITY AND ECONOMIC PROSPERITY INDEX," tech. rep.

[58] H. Busch, "Linked for action? An analysis of transnational municipal climate networks in Germany," *International Journal of Urban Sustainable Development*, vol. 7, pp. 213–231, 7 2015.

[59] J. Corfee-Morlot, L. Kamal-Chaoui, M. G. Donovan, I. Cochran, A. Robert, P. J. Teasdale, J. Corfee-Morlot, L. Kamal-Chaoui, M. G. Donovan, I. Cochran, A. Robert, and P.-J. Teasdale, "Cities, Climate Change and Multilevel Governance," tech. rep., 2009.

[60] S. Chan, C. Brandi, and S. Bauer, "Aligning transnational climate action with international climate governance: the road from Paris," *Review of European, Comparative and International Environmental Law*, vol. 25, pp. 238–247, 7 2016.

[61] A. R. Davies, "Local action for climate change: transnational networks and the Irish experience," *Local Environment*, vol. 10, pp. 21–40, 2 2005.

[62] H. Busch, *Entangled cities: transnational municipal climate networks and urban governance.* 2016.

[63] H. Bulkeley, L. Andonova, K. Bäckstrand, M. Betsill, D. Compagnon, R. Duffy, A. Kolk, M. Hoffmann, D. Levy, P. Newell, T. Milledge, M. Paterson, P. Pattberg, and S. VanDeveer, "Governing Climate Change Transnationally: Assessing the Evidence from a Database of Sixty Initiatives," *Environment and Planning C: Government and Policy*, vol. 30, pp. 591–612, 8 2012.

[64] A. . Hsu, O. . Widerberg, H. . Weinfurter, S. . Chan, M. . Roelfsema, K. . Lütkehermöller, and F. Bakhtiari, "Bridging the Emissions Gap: The Role of Non-state and Subnational actors-Pre-release version of a chapter of the forthcoming UN Environment Emissions Gap Report 2018 The Emissions Gap Report 2018. A UN Environment Synthesis Report ," tech. rep., 2018.

[65] S. Giest and M. Howlett, "Comparative climate change governance: Lessons from european transnational municipal network management efforts," *Environmental Policy and Governance*, vol. 23, pp. 341–353, 11 2013.

[66] K. Kern and H. Bulkeley, "Cities, Europeanization and Multi-level Governance: Governing Climate Change through Transnational Municipal Networks*," 2009.

[67] T. Lee and S. van de Meene, "Who teaches and who learns? Policy learning through the C40 cities climate network," *Policy Sciences*, vol. 45, pp. 199–220, 9 2012.

[68] M. Acuto and M. Ghojeh, "C40 Cities Inside Out," *Global Policy*, vol. 10, pp. 709–711, 11 2019.

[69] "C40 Cities: Why Cities are the Solution to Global Climate Change."

[70] "Fact Sheet: C40 Cities Climate Leadership Group," tech. rep.

[71] "Climate Action Planning Framework," tech. rep., C40 Cities, 3 2020.

[72] M. R. O. Marinello, "C40 and ICLEI to Establish Global Standard on Greenhouse Gas Emissions from Cities," 2011.

[73] "Global Protocol for Community-Scale Greenhouse Gas Emission Inventories,"

[74] "C40 ANNOUNCES NEW GUIDELINES FOR MEMBERSHIP CATEGORIES," tech. rep.

[75] "C40 Blog," 12 2015.

[76] K. Davidson, L. Coenen, and B. Gleeson, "A Decade of C40: Research Insights and Agendas for City Networks," *Global Policy*, vol. 10, pp. 697–708, 11 2019.

[77] T. Lee and H. Y. Jung, "Mapping city-to-city networks for climate change action: Geographic bases, link modalities, functions, and activity," *Journal of Cleaner Production*, vol. 182, pp. 96–104, 5 2018.

[78] "C40 Climate Action Planning Programme Vertical Integration Guide,"

[79] M. Fraundorfer, "The Role of Cities in Shaping Transnational Law in Climate Governance," *Global Policy*, vol. 8, pp. 23–31, 2 2017.

[80] G. Lindseth, "The Cities for Climate Protection Campaign (CCPC) and the framing of local climate policy," *Local Environment*, vol. 9, pp. 325–336, 8 2004.

[81] K. Davidson and B. Gleeson, "Interrogating urban climate leadership: Toward a political ecology of the C40 network," *Global Environmental Politics*, vol. 15, pp. 21–38, 11 2015.

[82] K. Attström, J. Leonardsen, C. Mørup, and H. S. Pedersen, "EVALUATION OF SUPPORT TO C40 CITIES LEADERSHIP GROUP FINAL REPORT Children's Investment Fund Foundation and Realdania Final report," tech. rep., 2016.

[83] "C40 Cities Finance Facility | Homepage."

[84] H. Busch, L. Bendlin, and P. Fenton, "Shaping local response – The influence of transnational municipal climate networks on urban climate governance," *Urban Climate*, vol. 24, pp. 221–230, 6 2018.

[85] M. M. Betsill and H. Bulkeley, "Transnational networks and global environmental governance: The cities for climate protection program," *International Studies Quarterly*, vol. 48, pp. 471–493, 6 2004.

[86] H. Zeppel, "The ICLEI Cities for Climate Protection Programme: Local Government Networks in Urban Climate Governance," in *Climate Change and Global Policy Regimes*, pp. 217–231, Palgrave Macmillan UK, 2013.

[87] L. Hakelberg, "Governance by Diffusion: Transnational Municipal Networks and the Spread of Local Climate Strategies in Europe," *Global Environmental Politics*, vol. 14, no. 1, pp. 107–129, 2014.

[88] F. Khan and B. K. Sovacool, "Testing the efficacy of voluntary urban greenhouse gas emissions inventories," *Climatic Change*, vol. 139, pp. 141–154, 11 2016.

[89] B. Steffen, T. S. Schmidt, and P. Tautorat, "Measuring whether municipal climate networks make a difference: the case of utility-scale solar PV investment in large global cities," *Climate Policy*, vol. 19, pp. 908–922, 8 2019.

[90] T. Oda and S. Maksyutov, "A very high-resolution (1km×1 km) global fossil fuel CO_2 emission inventory derived using a point source database and satellite observations of nighttime lights," *Atmospheric Chemistry and Physics*, vol. 11, no. 2, pp. 543–556, 2011.

[91] T. Oda, S. Maksyutov, and R. J. Andres, "The Open-source Data Inventory for Anthropogenic CO_2, version 2016 (ODIAC2016): A global monthly fossil fuel CO_2 gridded emissions data product for tracer transport simulations and surface flux inversions," *Earth System Science Data*, vol. 10, pp. 87–107, 1 2018.

[92] "Carbon Disclosure Project 2016 - Citywide GHG Emissions. CDP https://data.cdp.net/Cities/2016-Citywide-GHG-Emissions/dfed-thx7."

[93] "CARMA Revisited: An Updated Database of Carbon Dioxide Emissions from Power Plants Worldwide - Working Paper 304 | Center For Global Development."

[94] F. C. Hsu, K. E. Baugh, T. Ghosh, M. Zhizhin, and C. D. Elvidge, "DMSP-OLS radiance calibrated nighttime lights time series with intercalibration," *Remote Sensing*, vol. 7, no. 2, pp. 1855–1876, 2015.

[95] QGIS Development Team, "QGIS Geographic Information System," 2009.

[96] R Core Team, "R: A Language and Environment for Statistical Computing," 2020.

[97] G. Zhang, N. Zhang, and W. Liao, "How do population and land urbanization affect CO_2 emissions under gravity center change? A spatial econometric analysis," *Journal of Cleaner Production*, vol. 202, pp. 510–523, 11 2018.

[98] Y. Zhou and Y. Liu, "Does population have a larger impact on carbon dioxide emissions than income? Evidence from a cross-regional panel analysis in China," *Applied Energy*, vol. 180, pp. 800–809, 10 2016.

[99] S. Singh and C. Kennedy, "Estimating future energy use and CO_2 emissions of the world's cities," *Environmental Pollution*, vol. 203, pp. 271–278, 8 2015.

[100] Y. Liu, Y. Zhou, and W. Wu, "Assessing the impact of population, income and technology on energy consumption and industrial pollutant emissions in China," *Applied Energy*, vol. 155, pp. 904–917, 10 2015.

[101] E. Massey, R. Biesbroek, D. Huitema, and A. Jordan, "Climate policy innovation: The adoption and diffusion of adaptation policies across Europe," *Global Environmental Change*, vol. 29, pp. 434–443, 11 2014.

[102] L. Wei, C. Li, J. Wang, X. Wang, Z. Wang, C. Cui, S. Peng, Y. Liu, S. Yu, L. Wang, and Z. Shi, "Rising middle and rich classes drove China's carbon emissions," *Resources, Conservation and Recycling*, vol. 159, p. 104839, 8 2020.

[103] Y. Hao, H. Chen, Y. M. Wei, and Y. M. Li, "The influence of climate change on CO2 (carbon dioxide) emissions: An empirical estimation based on Chinese provincial panel data," *Journal of Cleaner Production*, vol. 131, pp. 667–677, 9 2016.

[104] X. Wang, D. Chen, and Z. Ren, "Assessment of climate change impact on residential building heating and cooling energy requirement in Australia," *Building and Environment*, vol. 45, pp. 1663–1682, 7 2010.

[105] K. Vringer, R. de Vries, and H. Visser, "Measuring governing capacity for the energy transition of Dutch municipalities," *Energy Policy*, vol. 149, p. 112002, 2 2020.

[106] R. F. Boehnke, T. Hoppe, H. Brezet, and K. Blok, "Good practices in local climate mitigation action by small and medium-sized cities; exploring meaning, implementation and linkage to actual lowering of carbon emissions in thirteen municipalities in The Netherlands," *Journal of Cleaner Production*, vol. 207, pp. 630–644, 1 2019.

[107] "Perceptions of government effectiveness and fairness," 2019.

[108] T. Nochta and C. Skelcher, "Network governance in low-carbon energy transitions in European cities: A comparative analysis," *Energy Policy*, vol. 138, p. 111298, 3 2020.

[109] M. Alkon and A. Wong, "Authoritarian Energy Transitions Undermined? Environmental Governance Cycles in China's Power Sector," *Energy Research and Social Science*, vol. 68, p. 101531, 10 2020.

[110] L. Hooghe, G. Marks, A. H. Schakel, S. Chapman Osterkatz, S. Niedzwiecki, and S. Shair-Rosenfield, *Measuring Regional Authority*. Oxford University Press, 4 2016.

[111] D. Wiedenhofer, D. Guan, Z. Liu, J. Meng, N. Zhang, and Y. M. Wei, "Unequal household carbon footprints in China," *Nature Climate Change*, vol. 7, pp. 75–80, 1 2017.

[112] J. Ottelin, S. Ala-Mantila, J. Heinonen, T. Wiedmann, J. Clarke, and S. Junnila, "What can we learn from consumption-based carbon footprints at different spatial scales? Review of policy implications," 8 2019.

[113] J. Minx, G. Baiocchi, T. Wiedmann, J. Barrett, F. Creutzig, K. Feng, M. Förster, P.-P. Pichler, H. Weisz, and K. Hubacek, "Carbon footprints of cities and other human settlements in the UK," *Environ. Res. Lett*, vol. 8, pp. 35039–35049, 2013.

[114] *Redefining "Urban": A new way to measure metropolitan areas*, vol. 9789264174108. Organisation for Economic Cooperation and Development (OECD), 2012.

[115] P. Kivimaa, S. Hyysalo, W. Boon, L. Klerkx, M. Martiskainen, and J. Schot, "Passing the baton: How intermediaries advance sustainability transitions in different phases," *Environmental Innovation and Societal Transitions*, vol. 31, pp. 110–125, 6 2019.

[116] L. Sun, W. Liu, Z. Li, B. Cai, M. Fujii, X. Luo, W. Chen, Y. Geng, T. Fujita, and Y. Le, "Spatial and structural characteristics of CO2 emissions in East Asian megacities and its indication for low-carbon city development," *Applied Energy*, vol. 284, p. 116400, 2 2021.

[117] S. G. E. Economics and u. 2014, "Do government ideology and fragmentation matter for reducing CO2-emissions? Empirical evidence from OECD countries," *Elsevier*.

[118] "Chapter 4. Exploratory Study | Elsevier Enhanced Reader."

[119] W. Haupt and A. Coppola, "Climate governance in transnational municipal networks: advancing a potential agenda for analysis and typology," *International Journal of Urban Sustainable Development*, vol. 11, pp. 123–140, 5 2019.

[120] "OECD Statistics."

[121] "Worldwide Governance Indicators | DataBank."

[122] T. Yu, G. Yu, P. Y. Li, and L. Wang, "Citation impact prediction for scientific papers using stepwise regression analysis," *Scientometrics*, vol. 101, pp. 1233–1252, 10 2014.

[123] "Parsimonious Model - an overview | ScienceDirect Topics."

[124] B. Zdaniuk, "Ordinary Least-Squares (OLS) Model," in *Encyclopedia of Quality of Life and Well-Being Research*, pp. 4515–4517, Springer Netherlands, 2014.

[125] S. Brookes, E. Whitely, M. Egger, G. S. J. o. c. . . . , and u. 2004, "Subgroup analyses in randomized trials: risks of subgroup-specific analyses;: power and sample size for the interaction test," *Elsevier*.

[126] I. Martínez-Zarzoso, A. Bengochea-Morancho, and R. Morales-Lage, "The impact of population on CO 2 emissions: evidence from European countries," *Environ Resource Econ*, vol. 38, pp. 497–512, 2007.

[127] T. S. Breusch and A. R. Pagan, "A Simple Test for Heteroscedasticity and Random Coefficient Variation," *Econometrica*, vol. 47, no. 5, pp. 1287–1294, 1979.

[128] C. Kim and B. E. Storer, "Reference values for cook's distance," *Communications in Statistics Part B: Simulation and Computation*, vol. 25, no. 3, pp. 691–708, 1996.

[129] E. Croci, B. Lucchitta, G. Janssens-Maenhout, S. Martelli, and T. Molteni, "Urban CO2 mitigation strategies under the Covenant of Mayors: An assessment of 124 European cities," *Journal of Cleaner Production*, vol. 169, pp. 161–177, 12 2017.

[130] R. K. Yin, "Case Design and Methods," *SAGE Publications*, pp. 1–265, 2003.

[131] "C40 Office in Copenhagen to Connect Cities and Businesses to Tackle Climate Change | European Cluster Collaboration Platform."

[132] T. Damsø, T. Kjær, and T. B. Christensen, "Counting carbon: contextualization or harmonization in municipal GHG accounting?," *Carbon Management*, vol. 7, pp. 191–203, 7 2016.

[133] T. Damsø, T. Kjær, and T. B. Christensen, "Local climate action plans in climate change mitigation - examining the case of Denmark," *Energy Policy*, vol. 89, pp. 74–83, 2 2016.

[134] S. Gössling, "Urban transport transitions: Copenhagen, city of cyclists," *Journal of Transport Geography*, vol. 33, pp. 196–206, 12 2013.

[135] W. K. Fong, "An Accounting and Reporting Standard for CitiesGlobal Protocol for Community-Scale Greenhouse Gas Emission Inventories," tech. rep.

[136] C. Municipality, "KBH 2025 – Klimaplanen. [CPH 2025 – the Climate Action Plan]," 2012.

[137] "C40-Bogotá ."

[138] C. I. Pardo Martínez, "Energy and sustainable development in cities: A case study of Bogotá," *Energy*, vol. 92, pp. 612–621, 12 2015.

[139] "Bogota Climate Action Plan," tech. rep.

[140] "Greenhouse gas emissions interactive dashboard."

[141] "Bogotá presents its Climate Action Plan In the framework of World Earth Day | Bogota.gov.co."

[142] K. D. Hernández and O. A. Fajardo, "Estimation of industrial emissions in a Latin American megacity under power matrix scenarios projected to the year 2050 implementing the LEAP model," *Journal of Cleaner Production*, vol. 303, p. 126921, 6 2021.

[143] C40, "Good Practice Guide - District Energy," tech. rep.

[144] N. R. Pulido, A. C. Poveda, and J. E. M. Carvajal, "Corruption and instutitions: An analysis for the Colombian case," *Heliyon*, vol. 6, p. e04874, 9 2020.

[145] "2020 - Cities Emission Reduction Actions | CDP Open Data Portal."

[146] "C40 Office in Copenhagen to Connect Cities and Businesses to Tackle Climate Change ," 2017.

[147] M. Mintrom and J. Luetjens, "Policy entrepreneurs and problem framing: The case of climate change," *Environment and Planning C: Politics and Space*, vol. 35, pp. 1362–1377, 12 2017.

[148] "Official Development Assistance (ODA) - OECD."

[149] G. Trencher, V. Castán Broto, T. Takagi, Z. Sprigings, Y. Nishida, and M. Yarime, "Innovative policy practices to advance building energy efficiency and retrofitting: Approaches, impacts and challenges in ten C40 cities," *Environmental Science and Policy*, vol. 66, pp. 353–365, 12 2016.

[150] C40, "Good Practice Guide - Municipal Building Efficiency," tech. rep.

[151] H. Bulkeley, V. C. B. T. o. t. i. of, and u. 2013, "Government by experiment? Global cities and the governing of climate change," *Wiley Online Library*, vol. 38, no. 3, pp. 361–375, 2013.

[152] C40, "Good Practice Guide - Low Emission Vehicles," tech. rep.

[153] N. Department of Environmental Protection and Ramboll, "Cloudburst Resilience Planning Study - Executive Summary," tech. rep., 2017.

[154] K. C. Roy and C. A. Tisdell, "Good governance in sustainable development: The impact of institutions," *International Journal of Social Economics*, vol. 25, pp. 1310–1325, 7 1998.

[155] V. Castán Broto and L. K. Westman, "Ten years after Copenhagen: Reimagining climate change governance in urban areas," 7 2020.

[156] "Soon, Cars in Denmark Will Only Be Taxed at 100% - Bloomberg."

[157] M. Heikkinen, T. Ylä-Anttila, and S. Juhola, "Incremental, reformistic or transformational: what kind of change do C40 cities advocate to deal with climate change?," *Journal of Environmental Policy and Planning*, vol. 21, pp. 90–103, 1 2019.

[158] "C40 Climate Action Planning Resource Centre."

[159] J. V. d. Heijden, *Innovations in urban climate governance: Voluntary programs for low carbon buildings and cities.* 2017.

[160] T. Lee and C. Koski, "Mitigating Global Warming in Global Cities: Comparing Participation and Climate Change Policies of C40 Cities," *Journal of Comparative Policy Analysis: Research and Practice*, vol. 16, pp. 475–492, 10 2014.

[161] S. Karhinen, J. Peltomaa, V. Riekkinen, and L. Saikku, "Impact of a climate network: The role of intermediaries in local level climate action," *Global Environmental Change*, vol. 67, p. 102225, 3 2021.

[162] L. Huang, S. Kelly, K. Lv, D. G. J. o. c. production, and u. 2019, "A systematic review of empirical methods for modelling sectoral carbon emissions in China," *Elsevier*.

[163] "The Future of Cooling – Analysis - IEA."

[164] J. van der Heijden, "Governance for Urban Sustainability and Resilience," *Governance for Urban Sustainability and Resilience*, 10 2014.

[165] T. Lee, "Global Cities and Climate Change : The Translocal Relations of Environmental Governance," *Global Cities and Climate Change: The Translocal Relations of Environmental Governance*, pp. 1–159, 8 2014.

[166] G. Li, A. Zakari, and V. Tawiah, "Does environmental diplomacy reduce CO2 emissions? A panel group means analysis," *Science of The Total Environment*, vol. 722, p. 137790, 6 2020.

[167] R. Alkhani, "Understanding Private-Sector Engagement in Sustainable Urban Development and Delivering the Climate Agenda in Northwestern Europe—A Case Study of London and Copenhagen," *Sustainability 2020, Vol. 12, Page 8431*, vol. 12, p. 8431, 10 2020.

[168] E. Sørensen and J. Torfing, "Co-creating ambitious climate change mitigation goals: The Copenhagen experience," *Regulation & Governance*, 2020.

Appendix A

Statitsical Analysis

A.1 Scopes defintions for city inventories

The GPC methodology enlists the scope emissions as: "The emissions occurring physically within the city (scope 1), from those occurring outside the city (scope 3) and from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross city boundaries (scope 2). [135]"
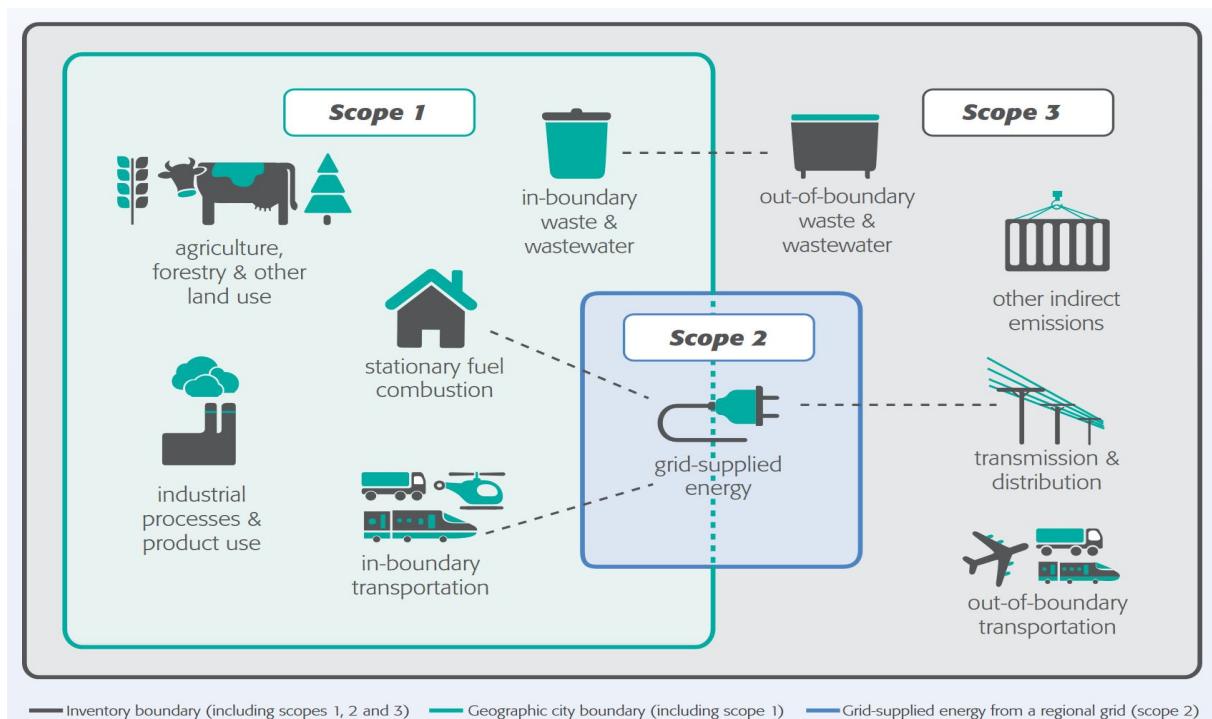
Figure A-1: *Sources and boundaries of city GHG emissions*

A.2   Figures
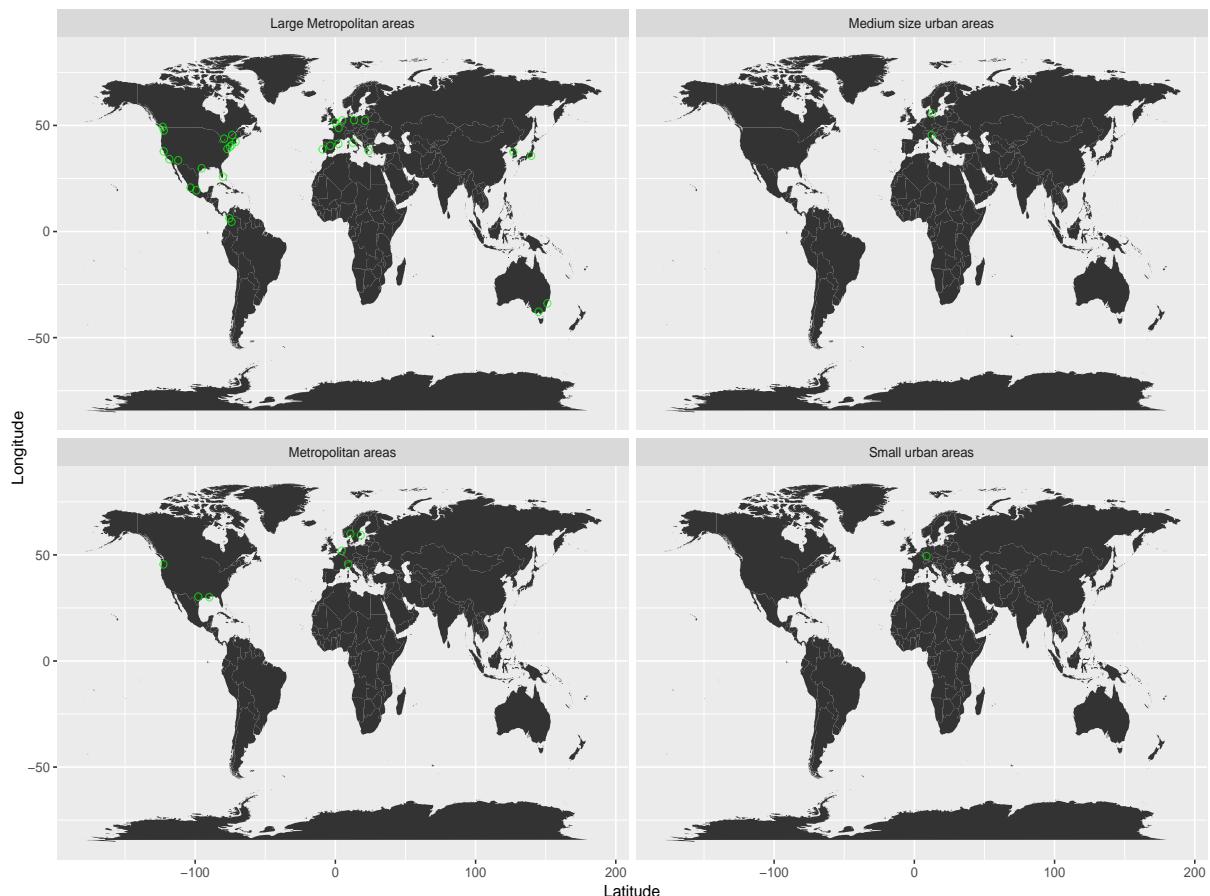
Figure A-2: *C40 cities categorised on their city urban size in the analysis*

It is can bee seen in FIg. A-2 that most of C40 cities are located in the global north and entails Large metropolitan areas profile. The only exceptional small municipality is Heidelberg in the C40 network from Germany owing to their successful history on climate action.
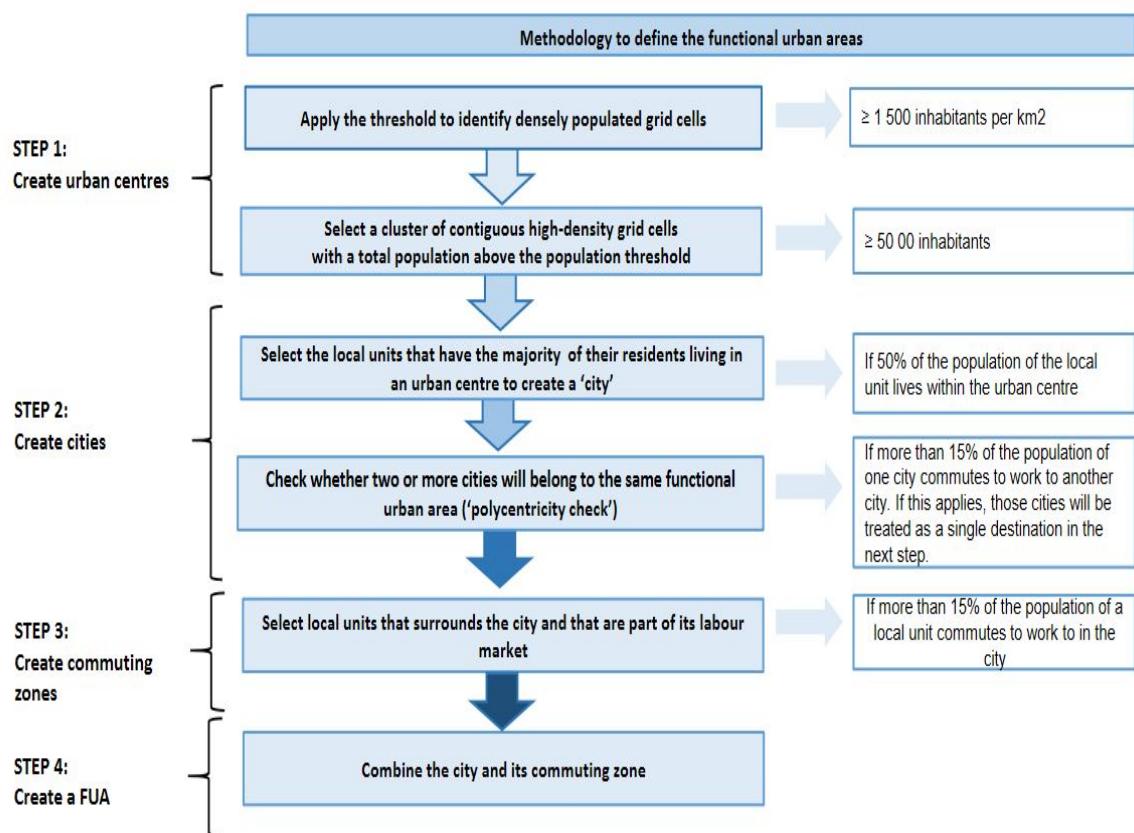
Figure A-3: *Methodology used to create the shape files for the city [9]*
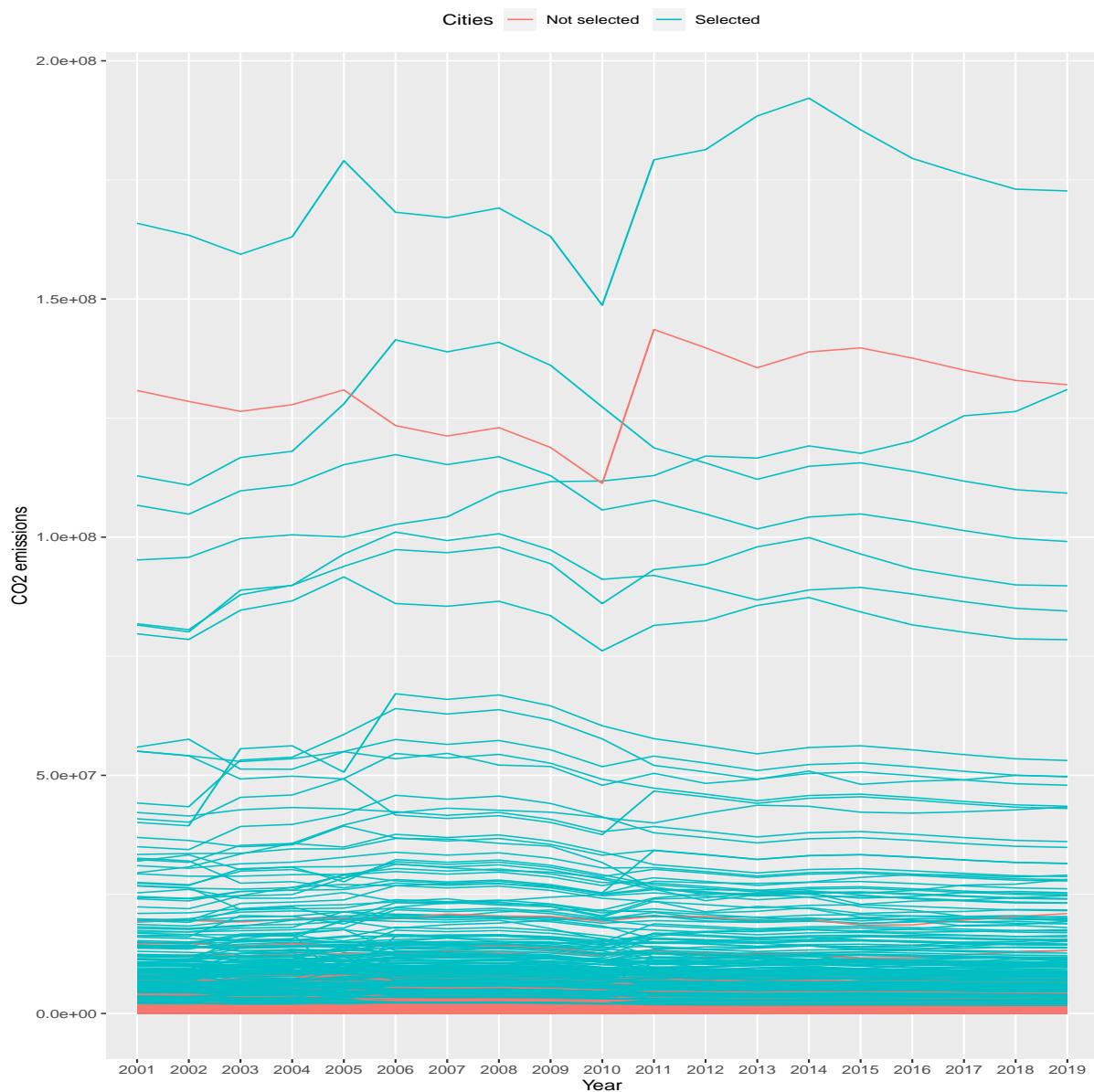
Figure A-4: *CO_2 emissions profile for selected and non-selected cities in the analysis*

A.3 Tables

Country	Large Metropolitan areas	Medium size urban areas	Metropolitan areas	Small urban areas
Australia	10	5	5	6
Austria	3	1	N/A	6

Country	Large Metropolitan areas	Medium size urban areas	Metropolitan areas	Small urban areas
Belgium	N/A	10	2	N/A
Canada	11	18	11	4
Colombia	5	15	9	1
Czech Republic	N/A	5	1	1
Denmark	N/A	8	N/A	7
Finland	N/A	N/A	5	12
France	6	18	14	26
Germany	8	35	31	50
Greece	4	N/A	3	N/A
Hungary	4	1	N/A	5
Ireland	N/A	3	N/A	3
Italy	5	26	20	34
Japan	10	34	28	2
Latvia	N/A	N/A	4	N/A
Lithuania	N/A	3	4	N/A
Luxembourg	N/A	N/A	N/A	1
Mexico	13	40	32	7
Netherlands	4	9	9	22
Norway	N/A	3	6	7
Poland	7	14	10	7
Portugal	6	N/A	3	2
Slovakia	N/A	4	N/A	N/A
South Korea	8	8	7	N/A
Spain	11	34	17	10
Sweden	N/A	1	10	3
Switzerland	N/A	1	N/A	11
United Kingdom	12	54	16	18
United States of America	130	133	138	25

Table A-1 continued from previous page

A.4 Robustness check

The robustness checks is performed to interpret the findings confidently. It is evident from all the checks that network membership had no significant statistical relationship. Interestingly, the regression between global north and global south, only CDD and national emissions were significant explaining the variance in the global south cities.

Table A-2: Robustness check on sensitivity of estimates with change in the dependent
variable

	Dependent variable:		
	Emissions change, per capita (tCO2)		
	(**Model1**)	(**Model2**)	(**Model3**)
C40	0.01	0.05	0.15
	(0.23)	(0.21)	(0.20)
National reduction	0.61***	0.86***	0.86***
	(0.03)	(0.05)	(0.05)
Population trend (number of inhabitants)		−0.72***	−0.77***
		(0.06)	(0.06)
GDP per capita ($)		0.03	−0.03
		(0.04)	(0.04)
Avg. Annual Heating Degree Days			0.0003***
			(0.0000)
Avg. Annual Cooling Degree Days			0.001***
			(0.0002)
Constant	−0.36***	0.34***	−0.53***
	(0.04)	(0.10)	(0.16)
R^2	0.20	0.33	0.36
Adjusted R^2	0.19	0.33	0.36
Note:		**p<0.1; **p<0.05; ***p<0.01*	

Table A-3: Robustness check on sensitivity of estimates with change in the dependent variable-contd.

	Dependent variable:			
	Emissions change, per capita (tCO2)			
	Model4	**Model5**	**Model6**	**Model7**
C40	0.14	0.08	0.16	0.04
	(0.20)	(0.21)	(0.21)	(0.18)
National reduction	0.92***	0.95***	0.95***	1.84***
	(0.05)	(0.05)	(0.05)	(0.18)
Population trend (number of inhabitants)	−0.82***	−0.81***	−0.81***	−0.79***
	(0.06)	(0.06)	(0.06)	(0.06)
GDP per capita ($)	−0.06	−0.05	−0.03	−0.05
	(0.04)	(0.04)	(0.04)	(0.06)
Avg. Annual Heating Degree Days	0.0003***	0.0003***	0.0002***	−0.0000
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Avg. Annual Cooling Degree Days	0.001***	0.001***	0.001***	0.001***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
'Government Effectiveness'	0.30***	0.39***	0.40***	−2.63***
	(0.10)	(0.10)	(0.10)	(0.91)
RAI	−0.01**	−0.01	−0.01	−0.13***
	(0.005)	(0.005)	(0.005)	(0.02)
Constant	−0.41*	−0.60***	−0.72***	8.30***
	(0.21)	(0.22)	(0.22)	(1.78)
R^2	0.37	0.38	0.40	0.55
Adjusted R^2	0.36	0.37	0.39	0.53

Note: *p<0.1; **p<0.05; ***p<0.01

Table A-4: Regression with alternate functional form of both dependent variable and co-variates

	Natural log of Dependent variable:	
	Emissions, total (tCO2)	Emission, per capita (tCO2)
	(1)	(2)
C40	−0.02	−0.02
	(0.09)	(0.09)
ln(National reduction)	−0.22**	−0.22**
	(0.09)	(0.09)
ln(Population)	0.86***	−0.14***
	(0.04)	(0.04)
ln(Population Density)	−0.13***	−0.13***
	(0.02)	(0.02)
GDP per capita	0.0000***	0.0000***
	(0.0000)	(0.0000)
(GDP per capita)^2	−0.00***	−0.00***
	(0.00)	(0.00)
Avg. Annual Heating Degree Days	0.0002***	0.0002***
	(0.0000)	(0.0000)
Avg. Annual Cooling Degree Days	0.001***	0.001***
	(0.0001)	(0.0001)
Government Effectiveness	−4.85***	−4.85***
	(0.91)	(0.91)
RAI	−0.01	−0.01
	(0.01)	(0.01)
Constant	14.44***	14.44***
	(2.71)	(2.71)
R^2	0.89	0.57
Adjusted R^2	0.89	0.55
Note:		*p<0.1; **p<0.05; ***p<0.01

Table A-5: Robustness check with alternate functional form independent variable

	Dependent variable:	
	% change, total (tCO2)	% change, per capita (tCO2)
	(1)	(2)
C40	−0.03	0.32
	(0.18)	(0.96)
ln(National reduction)	−1.88***	−0.22
	(0.18)	(0.94)
ln(Population)	−0.17**	−1.75***
	(0.08)	(0.43)
ln(Population Density)	−0.02	−0.65**
	(0.05)	(0.27)
GDP per capita ($)	0.0000	0.0002***
	(0.0000)	(0.0001)
(GDP per capita)^2	−0.00	−0.00***
	(0.00)	(0.00)
Avg. Annual Heating Degree Days	0.0000	0.001***
	(0.0001)	(0.0003)
Avg. Annual Cooling Degree Days	0.001***	0.01***
	(0.0002)	(0.001)
Government Effectiveness	−19.24***	−16.21
	(1.86)	(9.90)
RAI	0.03**	0.02
	(0.01)	(0.06)
Constant	58.42***	55.54*
	(5.56)	(29.62)
R^2	0.53	0.31
Adjusted R^2	0.51	0.28
Note:		*p<0.1; **p<0.05; ***p<0.01

Table A-6: Global North vs Global South regression check for robustness

	Dependent variable:	
	Emissions change (%), total (tCO2)	
	Global North	Global South
	(1)	(2)
C40	0.07	−0.005
	(0.21)	(0.24)
National reduction	1.00***	1.29***
	(0.05)	(0.25)
Population	0.18***	0.08
	(0.06)	(0.28)
GDP per capita ($)	−0.09**	0.01
	(0.04)	(0.11)
Avg. Annual Heating Degree Days	0.001***	−0.0002
	(0.0002)	(0.0002)
Avg. Annual Cooling Degree Days	0.0002***	−0.001*
	(0.0001)	(0.0003)
Government Effectiveness	0.12	
	(0.10)	
RAI	−0.01**	
	(0.005)	
Constant	0.03	0.45
	(0.23)	(0.78)
R^2	0.39	0.96
Adjusted R^2	0.38	0.89
Note:	*p<0.1; **p<0.05; ***p<0.01	

Appendix B

Interview Log

B.1   Interview 1

Background: Researcher with publications on C40 and former project manager in one of the TMNs.

Chitransh Lot: Okay, thank you for joining today maybe we can start with your introduction and then, I can proceed with the questions.

Interview 1: Okay, yes, so I'm I'm doing my PhD on environmental change and policy at the University of Helsinki and I'm working on the urban environmental policy and my thesis about the role of different networks in urban climate policy. So as part of my PhD I have studied the, the climate change mitigation and adaptation of services of C40 cities and then, I have one publication about the connection between adaptation planning process and network membership. Where I had C40 network and ICLEI and the Covenant of mayors, The global covenant of mayors and then, I have one interview-based article now in review about the network memberships in Helsinki and Stockholm. We have also one projects about the city to business network of city of Helsinki, that is now work in progress.

Chitransh Lot: You have an extensive background on the climate networks and highly regard your work in the article where you assessed the type of change which is brought about by C40 network. My first question would be that, C40 cities have helped its members in increasing their ambition on climate commitments.

Interview 1: Well, first of all, I need to highlight that, the interview based paper that is currently under review is about cities in global North let's say EU to be more specific and they all are capita cities so the results may not be applicable for cities somewhere else. Well in those cities or cases, I find that cities which are already quite ambitious apply to networks like C40 and they sort of use it as a way to keep up the ambition but it also has a very strong like political aspect so when I was talking with people who work with the climate issues in in in the city level they were especially in Stockholm They highlighted that when they are members of networks like C40 or such with high ambitions, that helps with their

case when they talk with the politicians, to give priority to the climate issues because of this international sort of image they portray as a part of the network even though there are no repercussion on not following on their "ambitious" commitments.

In the context of Stockholm, it is essential for the politicians to keep up with the idea that Stockholm is a green city and is on the forefront on the fight of climate change, although work of Busch showed contradictory results from German cities, where he said this kind of branding is not important for cities. So, then I think that probably it might be that in some other places like in cities that are not maybe don't have that much of a resources, for example, for the climate change mitigation, it might be that the significance of the network membership is different for them.

I also had one interview with a C40 representative, the EU regional leader, and according to her, the feedback from their members highlighted the importance of a climate advisor as it helps them in build their ambition but ofcourse, it's something that they are unable to provide to everyone.

Chitransh Lot: Would you say, the role of C40 differs between Global north and global south, as cities in global north are more progressive in regard with climate change and sustainability relative to global south cities?

Interview 1: I can't exactly say, but Anna Bach has done some research on it and I can forward you her contact information. She researched network participation in India and Denmark and she might have good insights on that. But as you know, C40 has been founded by London mayor basically with some other cities, but the initiative was originally from London and then New York, has been very active. They have really tried to make is global in the sense that they have been trying to increase the amount of cities and is true representation of a TMN, but looking at the foundation of the network, it is very north America and Europe centric. It is because of tendencies of forming best practice in this region and trying to import them in other cities. But from my interviews in Stockholm, I found that sometimes municipalities do more listening in the network and act as more passive rather than actually offering something to it. And it can sometimes become one way street and not really exchanging anything.

Chitransh Lot: Besides providing human personnel to some of the cities, I was wondering what are the other means that C40 uses to increase their capacity on climate change mitigation?

Interview 1: Well, yeah that has been something I have been doing the interviews for, and it appears to be very complicated, even for the city officials, to say the exact impact of C40 because, at least in in my case, when I'm studying this European city, they participate in so many things and also, it goes a bit like in cycles that, for example, at some point, they are very active in some network and then at some other point they move towards some other network. And, for example in the case of Stockholm I think they are now more involved in this carbon neutral cities alliance, which was the most important network including C40 when interviewing people from different areas, which could be because of its clear goal of to cut 80% emissions by certain year.

But the interviewees highlight, the information exchange opportunity to showcase their progress and solutions, and also, some specific projects such as different methods to calculate emissions

at niche levels, such as production of concrete. Which was I think done with cooperation of Chicago, Stockholm and C40 offered like resources to test and implement their methodologies.

And If I talk about Madrid, they used to have a office although, it sounds fancy, they only had two person but they had good contacts to the Mayor and within the city and also with secretary who is responsible for the concrete climate action in Madrid. Well, yes, the presence of C40 affects the ambitions level and offer new ideas and some people from the interviews, people mentioned the importance of having a representative as it also builds trust and transparency and you are just not engaging with some abstract organization. But it is of course very case specific. I would also very much like to talk about the political situation in Madrid, as the previous Mayor was pro climate policies and the current Mayor José Luis Martínez-Almeida who is not so much, so it would be interesting to see if things had change much from the time I interviews people in Madrid, but I don't know, although I feel it probably may have affected some plans.

Chitransh Lot: Yeah, even from my analysis, the addition of country variable, increases the explanatory power of the model significantly, so would you say the institutional dynamics in each of the cases you analyzed had some sort of impact in each of the cases or were there no differences.

Interview 1: Well, joining climate network, has definitely a showcasing for circle, especially C40 which is also a network of Mayors. Another thing to note, is that which cities are actually participating in C40, for instance, Helsinki is not a member have applied two times for membership and C40 denied because they believe Helsinki is too small and they are targeting only megacities, and also at that time, their focus was growing the network outside Europe to global south cities. So obviously they didn't want to increase the amount of European and North American cities. Then, if I understood correctly, after the second time they got rejected, Helsinki participated in some sub network of C40 as it was very interesting for them.

I also talked with one person who was involved in the membership process of Helsinki, and they were interested in the sort of 'branding' opportunities and also, C40 has good contacts from Bloomberg foundation which can aid in obtaining resources and other practical applications.

Chitransh Lot: That is very interesting! My next question for you would be, are you aware of the Hinku Climate network?

Interview 1: Yes I am aware of it but I haven't studied it specifically.

Chitransh Lot: That's all right. I just want to know on opinion whether local climate network like Hinku are more effective in the climate action.

Interview 1: Well, in the context of the European cities, which I know best, I think it might be because I'm well, as I said, these international networks, they might have like more political role, while in these local climate network, but national and local level networks, they might have more connection with actual implementation process. Also, in the case of international networks, it's quite typical that when you ask, at least in these European cases, if you asked like with whom they actually cooperate in the network, they often say "Yeah, well we cooperate with cities with same problems or similar characteristics". For example in Stockholm, they want cooperate more with Copenhagen and other Scandinavian cities. So in that sense, it is logical for national network to be more impactful as cities are relatively similar

and feel like working together and also perceive this sort of cooperation to more convenient and successful. And also the general criticism of these global networks is that, if something works in Sweden, it doesn't necessarily going to work in India or Italy for example.

Chitransh Lot: Wow, that is a very fascinating predicament to be in, don't you think? On the same note, you also mentioned this in your research and I also personally feel that, majority of the climate actions even from cities with vast amount of differences, they all appear to be very similar.

Interview 1: Yes, they are quite similar and well that's why I'm sometimes a bit suspicious if they're copying things from each other and not really thinking if it's actually working when they do the planning, I mean in general we have a quite a gap in studying the implementation project, and not only the planning part. So then it might be that in this kind of national networks it's easier to see what is going to work and what's not.

There was some other thing I was thinking about it to this. Oh yeah, then, then a contrary point to this. Well, in all the cities, I interviewed the people were saying that yeah well we participate in these international networks, because our city in the context of our country is sort of the exceptional because we are the capital city, we are the biggest city in the country leading the change. In the case of Madrid, there is only Barcelona, in Stockholm and Finland, Stockholm and Helsinki are the only big cities respectively, so they think for some things they need international contacts to the cities who are sort of in the same league. But in the case of Hinku, they have relatively all the small cities.

Chitransh Lot: From my interview from a C40 representative, she mentioned that their focus is more on the global south cities as compared to the global north to create this sort of climate equity. What do you think about that and do you have any comments?

Interview 1: Yes they have been doing that for a while and I hope they can make it work and its just not simply copying and pasting from global north to the global south.

Chitransh Lot: Well, that's all the questions I had and thank you for your time in helping me. I can perhaps stop recording the interview.

B.2　Interview 2

Background: Researcher with dissertation on emergence of TMNs and former work experience Municipality of Copenhagen.

Chitransh Lot:　Thank you for joining us, and thank you for taking time for this interview, and maybe you can introduce yourself and about your work.

Interview 2: Yeah sure, so my name is Anne Nelson and I'm a postdoc at the University of Copenhagen and I work, actually currently I work on Disaster risk management and climate adaptation and how sort of new communication technologies can improve cities sort of ability to respond to climate related threats and disasters but prior to this project, I did my PhD on transnational municipal networks. And looked mostly on sort of the implementation of policies across different cities and the extent to which this could be understood as a sort of international cooperation and the extent to which this was translated and adapted and in the local context.

Chitransh Lot: Since you have so much experience with the TMNs, my first question would be, do you believe that cities, who participate in the TMNs. Does these networks eventually help cities in increasing their ambition in terms of climate mitigation?

Interview 2:   So I think that's a good question and I think that's a question that many researchers are asking also that many city staff are actually asking themselves is sort of why are they participating in those networks. And I think my own research on this question shows actually very conflicting answers to this, so on one hand, what we do see is sort of a very strategic ambition for at least for many cities when they join these networks in the sense that they want to alter their policies on the area within the area that the team and concerns. And on the other hand, we also can sort of observe is that, over time, the reasoning around the participation actually changes, a bit. And also, the both the motivation and the reasoning varies across sort of city staff members and also across networks. So, I think it's too simplistic to say that there is sort of a symbol strategic rational reason for cities to participate, I think many of them have many sort of ideas of how these networks can potentially help them, so I mean both in terms of raising funding in gaining new information, I mean you know. You know the deal kind of functions that are that are often described in the literature as well, questions of capacity building. But when we then start to look at what actually happens, what plays out and then it becomes a bit more moderate the picture, so what are they actually learning. Are policies actually change because of the network, or is it because the city that take part of the network, I mean already have these types of policies and what we also do see is sort of a very. I would say sort of both symbolic and social logical reasoning around. Participation in the sense that they think it's important that cities take part in these major agenda, so it becomes a question of identity as well and sort of being. I mean living up to the role of being a city in in the times that we are living in, and at least for the major networks, such as the C40 and wonders in cities, and you have plenty of these major networks.

Chitransh Lot: So, what exactly if you have to think about the role of these are private networks, for instance like C40, what is their exact role in the in the organization of the climate action plans in the municipalities.

Interview 2:   I think it depends on the particular city, at least as in my research, shows that the roles actually vary quiet a lot, and that is you can't single out the roles of these networks. And, I have this concept that I use in my PhD dissertation and some of my work that I call that its cooperation without consensus. In that sense, you I mean you can kind of contrast it to normal International city or international diplomacy, where you have cooperation, building on consensus, so that you sign up or you take part in this organization and you negotiate particular goals particular measures that each of the Member States need to implement, whereas in in city networks, you see the dynamics are completely different and that they're actually rarely any consensus on what they are cooperating on. I think city's know this, or the TMNs know this and that is why you actually also see a change, for example, in C40, from this I mean a bit more loose networks towards being this extremely data oriented, as well as sort of goal focus network so, for example, the what are they calling the global deal program or something the 2020 program where they are sort of setting up and implementing climate and climate plans in a number of cities that one to partake in this.

So I think that's kind of I mean, I think that shows that they are maybe sort of moving towards I mean more traditional ways of thinking about this, but at the same time it continues to be voluntary, continues to be the cities that are often already really sort of find the game and so

yeah it's kind of a chicken and the egg problem here, I think it's very, very difficult to identify the causality and these questions.

Chitransh Lot: Okay that's interesting and I was thinking, I mean obviously these TMNs, develop these best practices from different cities which may lead to adoption by another city.

Interview 2: Can you provide an example?

Chitransh Lot: I mean, for example, how Milan is developing their bicycle plans and developing new bicycle routes and they have these best practices reports and but I mean it still remains bit unclear like how much of it gets implemented in reality.

Interview 2: Yeah and that's what I mean that's why i'm asking is because I think when you I mean, I think the idea of best practices is something that all cities want they all want to sort of mean showcase best practices, they all want to import based best practices. When when we start to look at well what are these best practices and how can we even understand the concept of best practices. Is it actually best practices, is it good practices or even sometimes best practices become really bad practices if it's translated into context where the local? Yeah, culture and ideas are not taking into consideration and you see a ton of examples of this, one of them actually being bicycling so we have this idea that yeah well, you can just take. I mean the bicycle infrastructure that you have in the Netherlands or in Denmark and then you can important to all a lot of different cities, but the fact that that the I mean the practice of bicycling is not just a matter of infrastructure, so of course it's important that you have the lanes, because that provides sort of the materiality to actually ride a bike. But it's just as important that you have people who actually I mean know how to ride a bike feel comfortable in riding a bike that you have I mean car drivers also knowing how to I mean consider a. bike drivers in the traffic, and also that you have sort of the habit of driving a bike and and we know that both good and bad habits are hard to break So if you have never rode your bike before to work, why would you start doing it because there is a bicycle.

Chitransh Lot: Exactly, and do you believe these TMNs have influenced, a city staff in at least in changing the behavior in some sense but, as you mentioned, I mean this may really not been translated into change in the social behavior of the people living in the cities, so how can these TMNs can overcome this, if if it's even possible to do that.

Interview 2: I think it's a good question. And I think many of us would want to know the answer to that. So how can they actually make an impact on this major issue, as well as we would like to, and I mean, at least understand how can we make people react to climate change, and unfortunately it's just a huge conundrum. But, we do know that it, it does have a lot to do with culture values, risk perceptions as well, as available and knowledge, and I do think that transnational municipal networks can provide or can fill out some of this space somehow. But it's just not a quick fix, unfortunately. And I think we need a lot more knowledge and a lot more studies trying to understand when these are faithful and when they are not a when we actually do see I mean good learning processes across cities, and when we don't see good learning processes across cities when they become pure symbolic actions because there is definitely also a big number of memberships that are just completely passive where cities, they are part of these maybe 10 or 15 networks. And then, at the end of the day it doesn't really matter it's just I mean because that's what you do and it looks good on your webpage and things like that. And then, on the other hand, we do see some networks that really sort of inspire cities and many of them actually, at least in in the cases that I'm aware of actually quite local or regional.

Chitransh Lot: So, would you say, since you mentioned, I mean there are some regional networks, for example, there's a climate network Finland called Hinky network and there was a recent paper published, which basically found that membership actually had a role in reducing the emissions in Finnish municipalities So would you say these local climate networks are more effective as compared to these TMNs.

Interview 2: I would love to say that I think that's a hypothesis that it would be interesting to test, but I don't I don't have the data, so I honestly can't answer if that's the case, I mean, but I think it's a good hypothesis. And I think in at least in the Danish context as well, I do see some good examples of sort of regional and local networking so either within Denmark or cross the Nordic countries, where they have actually knowledge exchange that makes sense and where they can take I mean where they can transfer projects and where they can actually learn from how things are done quite a lot. On the other hand, I also do know that politicians and also city staff, they feel hugely inspired by these I mean enormous or these global networks like C40, then the question is the extent to which is actually impactful and I don't think we really do know that at this point. The data says, I had a student who did a similar, who did a similar analysis comparing CO2 emissions quantitatively. CO2 emissions and sort of membership periods things like that, and the problem was that he couldn't really find I mean the data wasn't really good enough for him to actually make the argument, but maybe data has improved a bit.

Chitransh Lot: The other question I was wondering, I mean what are the barriers city's face in terms of implementation of the climate action plans?

Interview 2: I think you'll find me different barriers also depending on the local political, economic, social context. And I think if we take Copenhagen as example as an example, which is a good example, I think, first of all it's pretty important to understand that the Copenhagen Climate Action Plan has nothing to do with C40. This is a huge misconception, it has nothing to do with the 40 so for Copenhagen, for example, just to also give you an in sort of an idea of the complexity, the Climate Action Plan is done by the technical and environmental administration it's, of course, adopted by the City Council but it's sort of led by the mayor of the technical and environmental administration. They are part of climate alliance, whereas see C40 membership belongs to the financial administration and the economic and sort of Business interest of the municipality so this financial administration, of course, uses the technical outputs and the plans that comes from the technical admin and environmental administration. As well as actually some of the other administration to showcase in C40 because it's really, really impressive work and and Copenhagen has been on the forefront on this for a while, but it doesn't have any to do with this C40 membership. I mean this was adopted, long before the initiative was taken long before the mayor of the technical and environmental administration is actually extremely critical opposite C40. So, I mean, I think that that really shows, I mean how difficult this is, at the same time see C40 finds the city of Copenhagen extremely interesting because of the work that's done here so it really, I mean it really shows some of the complexity that we have these city networks. Which is it's interesting to see what will happen here because we just had a new mayor of the financial administration and he seems to be far less interested in C40 as well, so it's interesting to see if Copenhagen becomes more passive.

When, in terms of the barriers, I think they are there are plenty, I think for Copenhagen, and if you look at the 2025 plan, which is, I think, currently the most interesting one, so

the climate neutrality city. By 2021 there's actually done some really, really good work by a scholar called Stephen pollock where he compares these a sewer policies across Australia and Denmark and sort of, how they are measured differently, and then I mean on their own they're actually mean living up to the goals, because they are yeah playing a bit around with the numbers in a way that makes it fit but, of course, one of the major issues, even in a country that is very decentralized like like Denmark is and is that you don't have the authority or the power over many of the areas that are important for climate mitigation. So actually most climate mitigation policy is decided by the Parliament and the city has very little to do about it, and that is both when it comes to emissions. I mean locally, but also from industry and things like that, but also when you start to think about consumption and and how I mean, for example, how taxes are regulated, that is a state based power and not something that municipality can do anything about. So when the state, for example, decides to make small cars super cheap, as they did, then the 2025 plan has a huge issue because suddenly all the citizens of Copenhagen starts to buy these small cars because it's more convenient and many families are moving to Copenhagen and staying in Copenhagen, and they want a car which really messes up the budget for for the CO2 neutral target, so I think that's a really good example of how some things are just completely out of your hands, which is of course one of the major issues.

Chitransh Lot: Well, I mean that is that is very interesting and in the context of Copenhagen, would you say C40 provides support in regard to the capacity, more in terms of financing than technical capabilities.

Interview 2: I think it's I think it's I mean I don't know Copenhagen will enough, I mean I used to actually work for see 40 in Copenhagen, but that's six years ago. So, so I mean I think lots of things have changed so I don't know, but I think back then at least what C40 did was mostly I mean showcasing Denmark and showcasing and local a climate concerned companies by using Copenhagen as a case through C40.

So I think that was at least the major benefits sort of this idea of creating sort of green jobs in Copenhagen, making Copenhagen sort of the capital of green jobs, attracting international staff that would like to work in these areas and sort of yeah so, so I think that you at least used to be, to be one of the major upsides of that.

Chitransh Lot: Okay, and also, you mentioned the decentralization in Denmark, so would you say the institutional dynamics really plays a role in the implementation of the climate action plans, when it comes to reality.

Interview 2: Yes, I haven't seen a case where the local political, institutional dynamics are not an issue.

Chitransh Lot: And would you say that, there is a problem in the coordination between the national and the local policy linkage which may potentially hampers the implementation of the climate action plans.

Interview 2: I think it's I think it's a good question actually and I used to, I mean, I also argued that, in the Danish sort of media couple of years ago when the Danish Government created a new transport bill and building sort of bill and where I argue that they completely forgot the municipalities, and the potential capacity and that could mean that it's actually that that actually exist across the Danish municipalities and cities. So, I think that is the case, but I also think it varies a bit from policy area to policy area. And the problem with

climate change is that, even though we use this big fancy word when you start to sort of break it down, then it actually it is a lot of different things that we need to take care of. And also, these authorities are dispersed across different authorities also in Denmark, where actually find them on both state, regional and national or sort of local municipal and levels, which of course causes coordination issues, because it always does, when you have a lot of different players and Denmark is actually one of the simple cases I mean if you look to Germany, where you have a federal government, if you look to India, where you I mean equally have I mean the complexity of the governing of the governance system of many of the subjects it's so complex, and I mean you just get lost.

Chitransh Lot: it's a different ball game altogether.

Interview 2: Completely so as a member of the city staff, I mean who to coordinate with who has the responsibility. Can it even be done, and if you do things that you're not required to do, which many of these climate mitigation and adaptation, things are then you I mean, I think, new ideas and initiatives are easily killed by bureaucracy and then you see that in in many in many cases.

Chitransh Lot: How do these TMNs go about mitigating this (in-coordination) between the national and the city level of policy linkage, if they actually go about it, or they just simply focus on cities which I don't really think is the case.

Interview 2: Yeah I actually don't know. I think it's not very formalized in many of the transnational municipal networks and that leaves coordination to be quite fragmented and quite different across context. I've done a lot of research in Brazil and increase in personal inventory policies, you see, I mean it's, I want to say, a bit like India, and also Germany, when you have these federal federation's or a quasi federation's or whatever we want to call them. And the complexity of this sort of governance system is so high, then you also see, I mean and also when you start to bring in politics, so you have different parties being represented at different levels lobbying different type of interest, I mean, then it becomes a very, very, very complex game and it just becomes a game that's not just about coordination, but about I mean negotiation and compromise and what you see in, for example, the Brazilian context is that these TMNs, not the global one, so not C40 but the local ones and the regional ones which you have a known tradition in Brazil for transnational municipal networks and jurisdiction is much stronger and much longer than, for example, seeing Europe which is pretty interesting, since all the research is on Europe right but what you see here is that these municipalities, and also both the staff that works with these municipalities and with these networking dynamics, as well as the local politicians that they use these networks quite actively to protect and lobby interest of the local level towards the state. So, so in that sense, you do see that these TMNs can sort of shift the power game, a bit. And, and without saying that, without sort of having any evidence of that I think and hypothesis could be, also the case of Copenhagen. That the membership of C40 and this sort of subtle globalization of Copenhagen, as the city, so not just the C40 but all the dynamics that sort of engage with these networks and becoming a huge player has created a different position for Copenhagen to negotiate in State policies. Not, not the other cities in Denmark, but Copenhagen, specifically, and I think that brings around a whole new question about sort of equality between cities and the small cities or medium sized cities, what are their roles, most people live in those not in the big cities. So, I think there is a lot of different topics to explore here but, but at least I think these power dynamics are quite interesting. Also in understanding sort of what the city's gain from this that is not

necessarily to measure, a CO2 emissions, but it's kind of to actually have a say, maybe in national negotiations over climate policy and potential impact that is far more interesting and then the local level, as you to mission.

Chitransh Lot: It is interesting indeed because C40 is not only a network of cities, it is also a network of the most influential mayors in the world.

Interview 2:   And companies.

Chitransh Lot: Yeah and companies, indeed, because that's where I think that's one of the motivation for the cities to join the C40 because they have all these big philanthropist companies who provide the funding and networking and but yeah and it is, it is very interesting, indeed, but would you say that the expectations from these TMNs is bit exaggerated, or we are j expecting too much from these TMNs and not a lot of it is in their hands and when it comes to actual implementation or measurable impact.

Interview 2:   I think it's a good question, I think we don't know the data. I don't know the answers to this, and I also think that it's I mean, it's dangerous to look at this in isolation from the dynamics that exist in parallel with sort of participating in transnational municipal networks and sort of the indirect effects, potentially, and this makes it really, really difficult to study.

Chitransh Lot: Also, you mentioned indirect effects, what do you mean by indirect effects precisely?

Interview 2:   That could be, for example, the power game in the local context. I mean that you don't really can see yeah Of course you can look at it, if you look at concrete negotiations and the roles that are but I mean, for example, I mean I think a good example is this is when the US, I mean following Trump's. I mean yeah when he took office in the US and you had a lot of city mayors around across the US suddenly I mean claiming the responsibility and sort of the authority over the climate agenda such as the formation of We are still in climate network and that really shows, I mean the potential effect of this in I mean policy and politics, I think, more importantly, that when maybe you can't really measure this in in CO2 emissions, but it's still sort of part of establishing and changing the discourse around climate change and climate change institutions.

B.3   Interview 3

Background: Professor in Bogotá with research focus on Latina American cities and their climate responses connected to their international political agenda.

Interview 3: Okay well hello, my name is Ana I am professor at university of Javeriana Bogota, I am an assistant Professor and the focus my research is on Latin American cities and their climate responses connected to their international political agenda.

Chitransh Lot: All right, thank you, Anna, and so my first question would be since you already work in the international relations department and you have worked with a lot of global South cities, would you say, these TMNs like C40 has helped us cities in increasing their ambition against climate change.

Interview 3: I would go further and say more than ambition, they help set the agenda like if those cities that I mentioned, and even bogota, if wasn't part of it (C40), climate change will never be on the table as public policy for those cities and what my research show was that see C40, ICLEI first knows in the 90s, basically was key to put the agenda on the debate in the municipal halls all over Latin America So yes, but you have to keep in mind that Latin cities are completely different from Europe or other western countries in regard Is that you have to two phases, the face, where the city get their compromise they made their promises, so they took the photos in C40 summit, they publish in the case of Sao Paulo, very ambitious climate plan in 2009, but you have to look the second phase, which is implementation and. In the second phase, the transnational municipal networks didn't have much contribution in the process, because it's a very local process that demand human resources and financial resources, so yes, I wouldn't say increase ambition but set the agenda.

Chitransh Lot: Okay, speaking of implementation, since you mentioned like this whole process is divided into two phases and C40 or maybe these TMNs have a lot of influence on increasing the ambition or at least enforcing this responsibility of engaging in climate change action, but how much influence do they have on implementation aspect of it because I mean they can plan, a lot of things, but if these plans are not been implemented, I mean you really cannot see any measurable outcome.

Interview 3: I think they have their role is much more weak, and I would say, in many cases in non-existent and I think C40 and also the ICLEI have noticed this along the way, so they're trying to foster more the formation of human resources, for example, and let me tell you something about Sao Paulo when I did my interviews for my research, I went to Sao Paulo to do the interviews and they had one person in the environmental Secretary responsible for everything about climate change everything was in her hands and didn't have any financial resources is specifically for climate policies. There wasn't much she could do the and there is not much ICLEI or C40 could do in this case. And when I went to Mexico City to do my interviews, I went there, and there was an entire floor of the environmental Secretary response for climate change, there were almost 10 people working on this, they were able to do their own inventories so it will depend on the human and financial capacity of those cities, and this is each city has a structure and this structure can change when the mayor change so it's you have to look the political climate in those cities to understand the implementation, so I would say C40 or ICLEI or others don't have much power in this process, the difference would be 100 resilience cities program in which they send a person to write their resilience plan so this was a different strategy, and I think it worked well, so and for one case specifically e.g. for Rio de Janeiro, when the mayor was director of C40. C40 had one special assistant for the mayor so, which was a very qualified person, and so this also helpful in the implementation and besides all the difficulties in financial and human resources, structure and also the political game in a municipal hall.

Chitransh Lot: Would you say that the institution dynamics of a country plays a influential role when it comes down to the implementation of the action plans?

Interview 3: It's key, it's the central answer for implementing or not implemented, so implementation it's a very domestic process. And those networks have little impact on them and one important issue for implementation to go further, is public opinion, support for the climate agenda which in Latin America is not robust, so there isn't the awareness of this as a key issue for us, as we have to deal with poverty will have to do with lack of sanitation and

even the transportation, which is a key topic for climate in Latin America it's not view as a climate issue it's view as rise through a CV. So lack of public support also plays a role.

Chitransh Lot: Okay, and to the best of my knowledge, I think there's a C40 advisor in Bogota. So, how this C40 help cities in increasing their governing capacity or helping cities in finding more resources for the formulation and implementation of these plans, so I just want to say, like what I just want to single out what the exact role is for say for the increasing the input capacity for the for their signatories.

Interview 3: And so, if you look Santiago, Chile, you see that C40 and Bogota those cities have something that is key for diminishing decreasing emissions, which is investing in the transportation sector, specifically in the electric buses. And both Bogota and Santiago, less in Mexico City and Sao Paulo and Rio de Janeiro, C40 was key to help connect those cities, with a major company which is BYD, the Chinese company that produce electric cars, so making these bridges and connections, I think helped those cities, although, there is a lot of questioning of when does the private interest began, when does the public interest begin and ends and so on, but I think in those cases, it was key. You know Bogota just made a huge purchase of electric buses, Santiago, Chile it's on its way as well, so I think that was very helpful, the connection of BYD auto through C40. More than that, I have my doubts, I think it would be, it would be necessary to look into every specific topic in policy to see their impact, maybe Manuel can tell you something different, he he's been working with this for years, since the beginning so but, as I see the implementation faces restricted to political will, financial capacity and public support.

Chitransh Lot: But is C40 doing something about it, I mean they must have acknowledge this barrier when city's join the climate network so, are you aware of anything that's C40 is trying to do to overcome all these barriers to improve the implementation of the climate action plans.

Interview 3: I think so, but I think this has been a movement, more recently, for c40 when I looked from 2005 since the creation and to 2018 and I think this is a movement that began more I would say 2014. **Chitransh Lot:** I mean the literature on these TMNs also suggest, I mean it might be a case that these local climate networks, instead of these International Climate networks connecting large cities globally, these local climate networks might be more successful in climate mitigation.

Interview 3: I think, as I said, their key to faltering to maintain keep the agenda going and I could we could say for mayors in Latin America, the International advertisement of them is really important so mayor bias was not only into C40 because he is worried with climate change, he knew it was a platform to promote him politically and that's how politics works but you have to be aware of that. It's the same case now in Bogota where, the current mayor Claudia Lopez is clearly using the platform to promote herself. I was in the C40 summit in Mexico City in 2016 and it was you know. Bloomberg was very active back then and well it still is, but it had much more hands on deck that time and the discourse and the conversations in the corridors was most of C40 cities in Latin America, their Mayors wants to be the President. It's the same story with all the mayors both past and present.

Chitransh Lot: It's not only a network of cities it's also a network of mayors and it's also I mean each city wants to be the pioneers against the climate change because it's also helped their national image and also the international image in this world of climate action so there's obviously a lot of are clearly a lot of politics involved in it.

Interview 3: Reducing emission in Latin American cities requires drastic changes in the structure of the transportation sector which takes time.

Chitransh Lot: I's small chage, and a transformational change is required in people's behavior and the same in the infrastructure. **Interview 3:** Exactly exactly, and this takes time, it's difficult to see some results in reducing emissions, right now, maybe we could see in 10-12 years, 20 years I don't know, but the past has taught me , I'm being pessimistic here, but Sao Paulo is the key to understand Latin America, they approve a very ambitious law in 2009. They promise in this climate law that in 10 years they would become like by change in 10% of their fleet transportation flee to energy or more. In 10 years they would had 100% of the fleet transform. I was very excited about it as Sao Paulo is very polluted and what not, and how much do you think changed?

Chitransh Lot: Not much, I think.

Interview 3: 6%. Not even the goal of one year, so that in this was a law approved by the legislative power.

Chitransh Lot: But what exactly do you think went wrong in this period of 10 or 11 years.

Interview 3: So no public support for the agenda. So, no mayor is going to put his or her head over a climate policy in Latin America, if there is no public support. This is slowly changing now but it's still there is no huge support or support enough to win an election. Second, specifically, there are these huge transportation companies that rule, the public transportation sector for years, decades, and these would demand for them to reduce their gains and to make those changes. They never did, the other thing is weak rule of law. If this was a serious country or city, this should be implemented, but there is no accountability or monitoring. I'm sure in the Netherland, if you approve a law, you have to implement, and this is also my critique on the analytical framework produce based on the cases of Europe or the United States. The concepts in the literature doesn't apply to Latin America and I generated another framework which I haven't published yet.

Chitransh Lot: So would you say that C40 membership has helped these Latin American cities at all, maybe in terms of some co-benefits for example besides climate mitigation or reduction in emissions.

Interview 3: Although we don't see the full implementation of their promises, I do think it's very positive to be part of C40 or ICLEI or any other TMN because there are gains in the way that you wouldn't have otherwise. The first one is setting the agenda which I already mentioned. You can have some decrease in emissions, in some cases, it would be difficult to say if it is a result of the membership. But along the way, you also have. A more qualified personnel or human resources, like the people work in the cities and the Secretaries of participate in the workshops foster by C40 and the information stays with the city, so there is an intellectual human resources capital gain in the way. And specifically looking for C40 the cities which don't have to pay to participate, which is different for other international networks which can be a problem for them like mayors having a hard time justifying their fees to the citizens in participating in the climate networks. But at the end of the day, I think cities gain a lot by being at C40 a lot, and not maybe in the terms of their main goal which is to reduce emissions. C40 does support in increasing capacity for cities but that doesn't mean necessarily means reducing emissions directly.

Chitransh Lot: But from my analysis I found I mean see for the membership did not had any impact on the admissions at all, so in my data, temporal coverage was from 2001 to 2019 and given that C40 was established in 2005 would you say 15 years our time frame is not much to see any measurable outcomes in the context of Latin America.

Interview 3: For Latin American yes, but for other cities I don't know. It's not much time to make for example transformation, in the transportation sector but it's possible so, at least at this point which we could have, or we should expect, at least to see a trajectory change. I think with Bogota with this specific mayor, Bogota it's on its way in climate trajectory, but the pandemic came and things had to change, all the plans change, so I don't know how. Also, the change in mayoral power played a role in reality, as some shut down all international initiatives because of political conflict to make him different from his predecessors even though belonging from green party.

And, before I forget to the previous question if it's if it's positive being part of C40, I would add another topic which matters being part of C40, which is transparency of public policy so most not all but most of the policies regarding environment, climate change in the connection with C40 the public for all the cities, because this is a requirement from them, so this is again for citizens.

Chitransh Lot: Yeah I do feel, I think I definitely agree with you, I mean it's really hard to say and it's really hard to see transformational changes. It's really tricky to single out the effect of C40 memebrship and maybe you can see, C40 has really been not been effective, but maybe it's not really their fault as well.

Interview 3: yeah I think I think we need to be realistic C40 is not going to change everything and it's not their responsibility to do so.I seen the literature, sometimes that too much expectation from C40 like or ICLEI, or TMNs, and this is a local topic at the end of the day, so we have to manage our expectations from these TMNs.

And just to make more personal comment, I did work with cities as international consultant in Brazil, before I did my I started between my masters in my PhD. So of course I believe in cities, of course, I believe the responses and cities I work with them my research, then, but I also got to see how things work on the field, then it's a little bit different from the literature.

B.4   Interview 4

Background: Prior work history with Technical administration of Copenhagen and currently, working with DK2020 project.

Chitransh Lot: Since you've been working with Copenhagen and other Danish cities since 2009, do you think participating in these networks help cities in increasing their ambition?

Interview 4: Yes, yes, yes, yes, I do I think that and also for Copenhagen, when you are the capital of small country and Denmark is divided into 98 municipalities and Copenhagen is by far the largest so that you need to have peers from other countries to compare with and some in some sectors, some areas Copenhagen is leading, of course, wind turbines, another example bicycling. Also Copenhagen need to learn from other organizations and to increase the level of ambition and also to be part of this story, to be a part of a bigger larger family and not just capital from a small country. It is also great advantage to have this international

level, because the mayors and politicians in the local governments, they want to be part of the story, they want to be part of race to zero, for instance, where many, many cities all over the world, join forces and they use this, both internally and for the political process, but also in their the dialogue and lobbying towards the national level. See, we are ambitious, we apply to the larger story and we're not just five small municipalities in Denmark we are part of a large, large family with many, many municipalities and cities. So it's also a great opportunity when you want to change laws, for instance, in a country and increase your possibilities as much ability to implement your ambitious goals.

Chitransh Lot: And speaking on motivation of these cities, I was wondering, if or does the motivation differ for, let's say Copenhagen and for some other small Danish municipality participating in TMNs.

Interview 4: Yeah, I think well some of the motivations, it was basically it's the same. Like when it comes to inspiration comes to being part of a greater family, but I think for Copenhagen, as a capital I think it's also a question of having other larger cities to compare with to. Because Copenhagen is, by far, as I said earlier, is by far the largest municipality in Denmark, so there are not a couple of cities or municipalities that Copenhagen can compare with to develop things with but, but a lot of municipalities are quite small also the problems or the the challenges they face are different, because in Denmark, a lot of municipalities, of course, also have agriculture; open land, so land use is an issue. The challenges are different, so I would say the Copenhagen has additional motivation in working together with other cities.

Chitransh Lot: Speaking of C40 climate network in particular, what is their main input in climate mitigation plans?

Interview 4: When we started out in 2009 in formulating the first Climate Action Plan, which was revised in 2012. I'm not even sure that Copenhagen even was a member of C40 at that time, I'm not sure. You must correct me, what kind of member is Copenhagen in C40 as it is small city...

Chitransh Lot: Yes, actually, there are three kinds of membership offered from C40 and Copenhagen is the innovator city, which is the city having population less than 3 million or so.

Interview 4: Yes, I couldn't remember what it was called. What was really important was that the Lord Mayor of the city of Copenhagen at the time and he got interested in C40 and he was part of making joint and he was very interested in joining, and when you work in a city like Copenhagen with different administrations.

I worked in the technical and environment administration, who was responsible for climate action planning and the implementation of many of the project afterwards. You need to have good relations, and good cooperation between the administration's particularly between the technical administration and the finance administration. When it comes to implementation and financing and international relations, so that you make these connections and your work and in that point, it was very important that also the Lord Mayor got interested in C40 to increase the political awareness and ownership to the climate agenda, that would be my personal view. So an increased political awareness and ownership from the top political level in all administrations, I think that was the main advantage from the C40 engagement. At the time we did not know that there was anything called "Climate action planning framework",

which I think came after Paris agreement, but after it came and we stark working with it, I was really positive and happy to see it. Some might say, Danish municipalities are complex to understand and it's formal but I think it is exactly the way it needs to be and you can even talk about the framing that the wording and so on, you talk about that, and you have to integrate it into to local environment, of course, but it's specifically has focused on the larger aspects of climate planning context, the stakeholders, the implementation, the monitoring all these things which are so important, so it was just like what we have been doing in Copenhagen, so I really am a really positive, and when I read it.

Chitransh Lot: So, speaking of implementation, like what are the main barriers Danish municipalities face in implementation of the climate action plans.

Interview 4: Well, first of all, if you look at the sectors, you know energy buildings and the barriers are in transport and in specifically heavy transport of toxins and farming. And those are the main challenges when it comes to energy and buildings, the Danish municipalities have been working with this for many years. Although, it is not too easy, but they have the tools they have the legislation in place. The role of municipalities when it comes to energy and buildings are quite clear, it is embedded in the legislation, how and what role does municipalities play when it comes to, for instance, phasing out individual heated houses, phasing out oil, natural gas, they know what to do, they know how to do it, doesn't come easily but they know how to do it and they can do it, so the Danish municipalities when we reach 2030, the energy sector in Denmark, nationally and in municipality will be carbon neutral, that is a no brainer. Energy and buildings is easy, but transport is tricky there's, of course, both the private sector and the trucks. Although, municipality has less control how stop the usage of fossil fuel cars for instance, like like they can plan for charging stations, but they cannot put themselves up on their own, as it may not be legal for them to do so. So they have to make tender processes and choose the private company to establish the charging station. When it comes to truck from industries and on highways, then tool to regulate them by municipality is close to zero. Often in Denmark, there is European issue we have trucks writing from from Sweden, Norway and Denmark and down to, Germany and other way, and municipality have very little power to do anything about it. Ofcourse, they can form partnerships and binding commitments with local industries to be green and sustainable, but the influence is very very small. And the last thing is agriculture, DK2020 project don't operate with cities but with municipalities, so that includes agriculture and have measures pertinent to those areas.

Chitransh Lot: If I understand correctly, I mean the barriers would be the lack of jurisdiction from the municipality, and also there appears to be some mis coordination going on between different levels.

Interview 4: You're right and especially the agriculture sector, where I believe national government has not really been able to put much focus on, they are so focused on the national targets and need to reduce 70% emissions by 2030. So the resources haven't been used lately to mitigation emissions in that sector.

Chitransh Lot: Would you say this gap can be over come by TMNs of lobbying these kinds of interests in the halls of national government.

Interview 4: Some of them can some of them can, but not all of them. And some of them can also be overcome by dialogue with local farmers they're very interested in also in

transformation, some of them, but it is not efficient and it is going too slow and risk not harvesting synergy and we need the national regulations not to lose time. It is time sensitive, two year, four years, delay due to politicians, we don't have time for that. So we need national legislation to tell municipalities that you must do this and you get money to this in the market. So if you approve a Danish law, municipalities are given money from State to do so, so you have to make the laws, give the power to the municipalities and because then it's given by law, they have to do it.

Mandatory climate action plans for instance, it's not mandatory in Denmark to have an action plan, when it comes to mitigation so it needs to be mandatory, it needs to the give them money, give them the manpower, the knowledge and we have municipalities as small as 50,000 inhabitants. So there are lot of small entities and don't have the means to do it themselves. Also, they have financial limits on how much they can spend from their budget.

Chitransh Lot: In one of my prior interviews, one of the interviews quoted "Technical administration is critical of C40" and with the new mayor, Copenhagen may possibly become a passive member of C40. What's your opinion about that?

Interview 4: I do not know if they have been more critical, I cannot confirm that but you're right that I think it was same thing, I refer to when I said that it has increased the awareness from the Lord Mayor who's the head of the finance department and So I think it is correct that the finance department and the Lord Mayor has been more interested in C40 than environment department has been but the critical part I cannot confirm, I do not know that really. But I think the technical administration has focused very much on the specific sectors and the projects and to implement to so, and the international aspect is more founded in the finance department, so I think that part is correct.

Chitransh Lot: Okay, and you also mentioned for this project, DK2020 you also work with closely with C40 if i'm not wrong, I mean there's also a C40 office in Copenhagen, so what exactly is the coordination between the think tank and C40.

Interview 4: I mean the coordination is intense in DK2020 both formally and informally. For instance, formally, C40 is our knowledge partner, Simon (director in Copenhagen office) is part of steering committee and has completely integrated himself into the projects, so formally speaking, they make the decisions on progress and so on and has much to contribute at the leadership level. Another formal role, is C40 approves the plans after they are finished at municipal level and approved politically. C40 checks if the plans are aligned and just stamped them as 'Climate action plan'. When it comes to more informal and daily basis, cooperation, C40 delivers example from other cities, if they ask for best practices and so on and also providing workshops and conferences to different mayors; communicating that you're part of a bigger story and what you do is important, because what you do in your smaller municipalities can be translated into national reductions. Also providing tools, checklist, knowledge on various topics and themes, so that's one of the examples how C40 has aided Danish municipalities.

Chitransh Lot: What's the plan to monitor the implementation of all these plants from the municipalities?

Interview 4: And two answers to that, first answer is a couple of weeks ago. The municipalities that have approved the climate plans have joined together to form climate alliance to

help each other in implementation. The part of this is developing a monitoring system, and through climate alliance.

After DK2020, which end in 2023, we hope Climate Alliance will be the framework which is driving the implementation of climate action plans.

Chitransh Lot: Does C40 plans to monitor this or their role ends prior to this?

Interview 4: C40 will help to develop the monitoring system in the climate alliance. If they have any further plans, then you might have to ask them yourself about this. I would guess their focus would be on inspiring other countries, in the implementing the same kinda project like DK2020 as it is great potential, if you know when you have many municipalities in the common country to join in and we are, of course, helping C40 in providing best examples and practices to share with others.

Chitransh Lot: That is interesting, although, it would be strange step for C40, now focusing on establishing these country level network like DK2020, which leads to one of my hypothesis that local networks might be more successful as compared to international climate networks.

Interview 4: Yes, I would say that I would say that when you develop the monitoring system, you need to have solid local knowledge on what is meaningful to monitor. And, as both of us probably knows developing a monitoring system is high politics, because what you're measuring, measured on this is really important if you're a success or not success, when it comes to your local coaches and so on, if you come on come out negatively because of a monitoring system, that really bad for the for the implementation of your plan and the political commitment. Further on I think many municipalities would say that it is administratively challenging with these reporting system internationally.

Chitransh Lot: Why is that the case?

Interview 4: When it comes to monitoring systems. When you develop them, you have to be sure that the people that deliver the data also get equally benefits from the developer to deliver data to back to them, because if you just deliver the data into form so many tons of CO2 so many bicycles and so many and you don't have anything back what can I, how can I, how can I use data from from other countries, can it be simple, can it be compare.

Chitransh Lot: On that point, would you say it's the lack of incentive from municipalities on reporting the data or the lack of competencies in actually knowing what to do with the data.

Interview 4: It is the first, municipalities know what to do with the data themselves, and when they can compare the data with their neighboring municipalities that's easy. Because they know each other, in Denmark, we have national web page they can look up and see how much each municipality use the current accounts what it looks like from this different sectors and so on, so that's easy and it is easier to compare emissions between Danish municipalities but not quite so if you're doing it with American or Canadian city as there are so many differences that needs to be accounted for and all of it comes with lot of buts. So I think you have to be very, very, thorough in what the data is useful, and is at what level, and if you if you ask municipalities to put in a lot of merit detail in data, it's very hard to see. Why, because it is so difficult to compare cities with district heating cities, with air conditions with, and so on, so so and agriculture and bicycle or many more. Also, the division between national level and municipal level, city level, how does this thing affect each other. In Denmark, you can

have municaplity's with a falling carbon emission and it's only because of national efforts in putting out for instance wind farms. And their emissions might be falling but in reality, they may not be doing anything.

B.5   Interview 5

Background: C40 administrative staff deployed in Latin America.

Chitransh Lot: OK, so my first question is, how does C40 help cities in improving their governing capacity and increasing their ambition?

Interview 5: Well, we bring the mayors together based. And what we ask them to commit with, which is Deadline 2020 and their commitment with that includes an emission reduction commitment by halfing the emissions by 2030. And becoming carbon neutral by 2050. So, at least in Latin America, we got the 12 cities we work with all signing Deadline2020. The tool for this is a Climate Action Plan and all cities have a Climate Action Plan. One city is finishing, actually two city are finishing their climate action plan, so the Climate Action Plan is expressing that commitment for 2030 and 2050. Not all the cities are going to have emissions by 2030, but all the cities are going to be carbon neutral with some residual submissions that are going to be handled by the end by 2050.

So that's, the first thing I want to mention the second thing I want to mention is that, anyways with or without plan cities are doing a huge amount of actions, they have a huge amount of projects and they invest in in many, many actions. And we highlight those actions, especially when they are mostly related to climate change, and I want to say there is nothing a city can do without being connected with climate change. So the beauty of the actions is that we highlight the benefits of those main action in say transport, say waste, say energy, or buildings, be more efficient in different subjects and so on.

And, and then the third point is that we connect the cities, we connect the mayor's we connect the city officials for them to share and learn around the best practices in different areas, So we have 18 networks that help us to do that job with the cities, but I want to highlight that in North America, most of the cities are very interested in transportation and clean energy. And there are many other things, of course, they are working, but they want to, to have a lot more impact in those areas, and we are helping a lot see cities to do that. And the fourth subject is, that as much as possible we bring tangible solution to cities, so we got some funding from the UK Government that help us to help the cities. To prepare the climate action plan, but we also have some projects like zebra. And the thing is that this is a project that is bringing some money from P4G. And that is helping us to help the cities to speed up the transition into zero emission buses. I have been working for more than a decade on clean transportation. And I have been advising series on how to move faster in that line, and since three, four years ago, things became a reality, I mean the speed of the transition became very high in some cities that we began to work with, so we created a lot of confidence on the technology. On the reason why zero emissions is important to reduce emissions on the operators bus operators that didn't know that technology and other cities, because the status of the end of the day, needs to offer the service and the service needs to be reliable, not always comfortable, but as much as possible, clean, because they all the cities need to reduce a emissions not only greenhouse emissions, but particles pollution, air pollution and

that's of high interest of most of the cities. So those are the main areas we are working in and we keep you know, bring in more and more technical support as much as possible, but we are not a specialized institution on clean transport or clean energy or the line we connect the dots we bring the best knowledge to says.

Chitransh Lot: How does C40 brought climate change on the agenda in the context of Latin America?

Interview 5: Put it this way it wasn't an agenda, many years ago and we accepted that because climate change was so extreme subject for many Mayors. But we, what we need, with the mayor's was to let them understand that everything they do in the city is connected to climate change. Either to increase or to reduce emissions, there is an impact always as much as you use energy, even ourselves; we are having an impact on climate change. So what we highlighted was the benefits that they could bring for their sake, their political sake explaining how important was the actions they were taking regarding climate change. Until climate change became part of the agenda, for instance, the Mayor of Buenos Aires, was selected using the climate change agenda as a political flag . And it doesn't happen like that everywhere, but now, Mayor of Bogota, the Mayor of Mexico City as well, and many Mayors now are using climate change as part of their agenda with specific targets.

Chitransh Lot: What are the challenges cities might face in implementation of climate action plans?

Interview 5: As of today the pandemic is playing a very, very strong role regarding the speed of implementation of the climate action plans, regarding money, regarding the ability of the cities to put things in motion because the cities are, I mean their finances in a very weak situation. So that is perhaps one of the biggest challenges we have today.

So we really want to help cities to try and transition into green jobs recovery, green and just a recovery, and this is taking time, it's becoming difficult and it clearly is not happening at the speed that the society is expecting to have, so that is a big challenge and and it's connected with the financial health of the cities. For instance in transport, cities lost income because there was no passengers for many months because we were were locked down; so no passengers, no income, and still the system needs to be paid for, and so that was a huge hole where all the financial structure of the cities. So and it's going to be like that, for many more years, perhaps because recovery is going to take time, so the cities are lacking money, cash flow income and the debts are need to be paid, so we are working with the multi auto banks and many institutions talking about how to help the city to cover that financial situation that is lagging is is making you know things is lower, so the problems that were supposed to be solved yet, they just grew.

So that is a huge challenge, despite of that, there are cities, that are trying to move on with the scarce resources they have. And I want to mention Mexico, Bogota, Buenos Aires and so on, but they did a, a lot of support. The other challenges is that the political conflicts that sometimes arise between the local government and the national governments. And Brazil is a typical case, bogota is also a little bit the same case, but the Mayors are trying to manage, you know the relationship.

Chitransh Lot: And what about the public support in the Latin American cities.

Interview 5: The only problem is that the time scale of the risk is different. The time scale of the human being is is very short it's very difficult for a human being to think in the long

term and to act facing the long term. And this is a permanent challenge, but the more you do things produce actions to sort out certain problems and you connect the dots with the long term, the more people is understanding the process and I want to bring attention, or the example of clean buses. When you bring clean buses, you're sorting out the problem that today's the right now problem of pollution, emissions particles, but at the same time you're telling the people, this is a solution in the long term, because we are breathing better today but we're reducing greenhouse gas emissions that are going to help us reduce risks. In the in the long run, at the same time, so this is connected and it's a matter of how we tell the people. Or the importance and the benefits of climate change, and this is the role of the Mayors and we help of course.

Chitransh Lot: Okay! So, how does C40 plays a role in orchestrating or an organizing everything at the municipal level and also ensuring coordination with all the relevant stakeholders?

Interview 5: Well let's make a point here we don't connect with walk out population as such, we connect with the cities and mainly with the Mayor and based on what cities, let us do, then we spread our reach, out towards other stakeholders. So the main one is the Mayor, or the second one is the staff of the mayor. And and a few of the institutions that work in certain areas, but we work based on the priorities of the mayor. So if the priorities is economic recovery, then we're trying to get involved with the institutions that are working on that. Actually, the subject is transport, clean energy and finance, this are the mains and of course vaccination vaccination, vaccination, vaccination. So we got involved in the best vaccination subject because there is no recovery if most of us are not vaccinated that is clear, so if we want to talk about recovery, we need to talk about about vaccination. So we help the cities a little bit in that and we connect the dots and so on. So, then, we, with the support of cities we move, use people or the city's make the move, so they involved user groups groups of people, young people to participate in different advocacy lines regarding climate change or actions, and now we are also working a little bit not actually not too much in like America or almost nothing like America with unions. So, we are you know working some somehow with unions for them International Union for them to prepare to advocate for climate change actions and support cities through the local unions, that are connected with the international units. But that's something is not working quite well in Latin America, because there is always a conflict between unions and political representatives mayor's mainly, sometimes, in many cases. And financial institutions so that's one of the subjects and bus players and electric energy cleaner you supplier, so we connect the dots demand, supply always in the middle financial institutions like so.

Chitransh Lot: What are C40's plan moving forward in monitoring the implementation of the CAPs?

Interview 5: The plants have battery of form of all kpis and that batteries kpis is connected with the monitoring and register monitoring registration MRV and verification. And registration, because in some countries, you need to register directions in order to for the national government to evaluate how much effect is this actual having in terms of emissions reductions or other subjects. So, we put a seal on the climate action plans, when they comply with certain criteria that we said. And one of the criteria, was the monitoring structure tools that we were putting in place for the climate action plans, so we are monitoring and the cities need to report on the advances of the climate action plan. Year after year and we for that purpose,

we have we have important for many years, with the platform that is called CDP as they are tracking actions from the climate action plan and putting them into the platform, so we have the structure to to track that process, then there are there are some leadership standards on one of those leadership standards is that the city needs to update every two years, maximum four years the inventory.

Chitransh Lot: I find C40 data oriented approach quite fascinating, but I need to mention the fact that most members in these TMNs are usually from global north cities, so what exactly for you are key differences between the two divide?

Interview 5: Right so. There are several things in general, I may say that the global north cities are richer than the global South seas. The second thing is global North cities have sorted out many subjects like, for instance, public transport is the public transport is there already for 100 years or something like that. In global south cities, we are still trying to build all of many, many public transport networks and so on the other subject, and that makes a difference is that because of that difference in in wealth you get more funding for technical support, technical assistance for global South cities. The other subject that makes a difference is that the priority in global North series is energy consumption in buildings, whereas in the global South cities, most of them is energy consumption in buildings, is not as big as it is in the goal South North cities, and that makes a difference in terms of priority actions regarding climate change. And that is another subject so when you compare the priorities in the global north versus global South, then you see different kind of priorities in. For obvious reasons, then when you're talking about creating jobs, sometimes the global North see if they have more ability to create jobs, they have more ability to bring investors private sectors on that that they global south it's very hard, because in many gold South cities, informality, is huge and where informality bigger than them formality, then creating jobs becomes formal jobs, becomes a very big challenge. This is a big difference again between the two, the two groups.

Chitransh Lot: One of things which has been highlighted in the literature of TMNs, is that climate action plans of global north and global south look very familiar, which makes the case of copying and pasting.

Interview 5: One of the rules that we set before this bands, is that a consultation process needs to be taken into account, now it is OK, you know not to copy and paste which is not happening regarding the kind of action plans, because all the plans were tailored city by city. What is good, is to learn how other cities are doing things. So how global north of it is how sorted out certain problems so transportation, so it is going to be metro system or is going to be BRT (Bus Rapid Transport) systems. Very few global North cities have a real BRT system, and this is a difference between global North and South, because a BRT system can be put in place in in a faster way and in a cheaper way compared to metro line. So that makes a huge difference regarding a clean energy and buildings you don't need to do too much in the global South you know regarding business, you can be need to be more efficient in terms of heat waves, waste, perhaps, and you know cooling buildings, but you don't need to heat buildings, when you need to cool, I mean you cannot copy paste a Climate Action Plan for the global North based on heating buildings So cities have similar powers, many have hours on transport, many have powers on electricity, many have powers on waste, so of course you need to tackle similar things in a different way.

Chitransh Lot: And that's where I guess the C40 comes in just connecting the dots.

Interview 5: Yes, bikes, for instance bikes of course bikes, the US didn't have any bikes any bike line it didn't exist at all, they are now learning from the global South. A little bit from from Europe, but Latin America started 10-20 years ago with bike lines, based on the example of the global North actually Europe, that's it. And now the Latin American citizens are examples for all the cities around the world, of course, except some cities in Denmark in Holland and or Dutch on that so on but London didn't had a space for line and they learned from us.

Chitransh Lot: Thank you Manuel. I don't have any further questions, I was wondering if you could send me over the signed consent form after this meeting, when it suits you. **Interview 5:** I need to look for that, because I never pay attention to bureaucratic processes, honestly, so my point is, if you like, that i'm saying go ahead in this is the recording i'm consenting the use of all this information that I have given today.

B.6   Interview 6

Background: C40 staff based in Copenhagen. The interviewee refused for the public release of the transcription.

B.7   Focus group

Background: Focus group with 8 civil servants of Bogotá municipality representing different departments such as Mobility and Transport, Environmental, Internation relations and Financial department.

Chitransh Lot: What is the motivation for Bogota to join C40 cities network and also, if the motivation differs between the departments?

Participant 1: Bogota is being part of C40 since 2005, we have been joining declaration and in general, it is part of the commitment from C40 to commit to these declarations.

Participant 2: Climate action for this administration is one of the most important things we are working on and C40 provided two important scenarios, one is political and the other is technical. Mayor Lopez is part the vice president of the steering committee to showcase Bogota and to learn what other cities are doing. But also, the technical aspect is very important, Sara can tell you about it more, and we also work in different sub networks to tackle mitigation, food security, adaptation, waste, etc.

Participant 3: I work more on the technical side and mostly liaise with C40 for technical side. One good thing about C40 is being part of the network and signing the declaration, which give us a lot of motivation to start our climate action plan and they also provide us some resources such as financial aid to pay for technical consultancy and also a lot of technical assistance from C40 itself.

Participant 2: I just want to add something on the political aspect, which is very important for us, for example C40 allows the mayor to connect with other mayors and talk and discuss about the similar problems and enjoy some coordination and Lopez also met with director of WHO, and also provide mayor different political scenarios which are essential for the mayor.

Participant 4: I'd also like to add possibility of the technical exchange, we are part of clean construction form, which is one of our top priority within the climate action plan, so it's these technical gaps that C40 really helps bogota to be more engaged and inclusive in their plans.

Chitransh Lot: Speaking of status-quo, does municipality of Bogota have enough human resources and finances to implement to their climate action plans?

Participant 3: It is bit tricky at the moment with the pandemic and as you know it is a 30 years plan and it is a commitment and some of the actions are financially ensured as they are part of the district plan for the development that municipality is committed to implement in the four years of government and what we have to do now is that ensure politics and norms starting to deliver now and and I also wanted to say that assistance C40 gave us last year was very very important and the methodology they provided help to make the most inclusive and detailed climate action plan. And speaking of assistance we could just call them and we ask for help through emails and we also had a technical team that was part of C40 and more specialsed work what was needed to do. So, the technical assistance overall was really helpful and it was very useful to have clear steps on what needs to be done and they provide tools on how to do things. We are still using the tools they provided and also gave us meetings ton understand us better on how to do it. I do think it very important and we could have some exchanges with cities which are ahead with their plans and help us learning and see how they have done it and it was really useful. After we finished CAP, there was a team who reviewed it and we got feedback and it was necessary to have some external help with no political outlook and no political agenda and I think this was really helpful and that's why this CAP was the most successful one.

Chitransh Lot: I have two follow up questions on that. How long does it take in formulation of CAP and has Bogota always been this active within the network?

Participant 2: When new administration starts, C40 proposes a participation agreement explaining what C40 wants to do with the city every period. Before Lopez, the administration did work with C40, but maybe not with the same level of intensity, I am not sure I was not in charge at that time, although, after Lopez being elected, Bogota has been very active within the network.

Chitransh Lot: Does C40 only works with the environment administration or with other departments as well?

Participant 3: Yes, with mobility. Diana perhaps you can answer that question. You have close relation with C40 as well right.

Participant 5: Yeah we are working with C40, some declaration like some commitments. One of the biggest challenge is to meet the goals set up in CAP, you know they are quite ambitious and to achieve that we need resources and post pandemic, resources are quite scarce, which cause challenge in decarbonization and improving new technologies. BUT, linking all these transportation and sustainable mobility projects within the climate action plan, will help in financing of these plans. Now with C40, we have this commitment to have zero emission by 2030 and zero emission buses by 2050, Maria are we working with some other declarations.

Participant 6: No they are the only two I am aware of.

Chitransh Lot: How is the inter- coordination within the municipality?

Participant 2: C40 coordinates first with the international relation department and after that all the information is communicated to the technical teams.

Chitransh Lot: So you would say it's pretty smooth.

Participant 2: Yeah

Chitransh Lot: And how does the support from the national government in terms of support scheme or policy linkage?

Participant 3: We have a dialogue with the ministry of environment and they are responsible for he implementation of NDC, and also this year they have the actualization of NDC and city is making contribution in some of their plans. Also, we are working on the articulation of the all the monitoring system which needs to be aligned with country level, we need to use same methodologies and how they are complying with the NDC. And national government have some territorial plans, and where all the cities and the departments define their strategical actions that need to be implemented in the regions. So this is huge help as a city, as it allows better communication with other cities and potential actions that can be implemented. And we have good communication with the national government, maybe Oscar can talk about the event we had which was very successful.

Participant 4: It was meant as an open event that was two weeks, and one of the main reason was for cities to socialize, especially for Mayor who is the vice president of the steering committee and one of the main aspect which was very crucial was we ensure attendance of several cities in Colombia, we also invited Bueunos Aires, as fellow vice president of C40 but also to integrate national institutions from the get go, like we had the privilege of having national planning department, and minister of environment which have also carried out different projects regarding monitoring, reporting, evaluation regard to climate action which was their main contribution as well as discussing plans for financing the climate action plans. So that was like front of cooperation from the political side and create visibility for cities.

Chitransh Lot: Does municipality have the regulatory authority to over the intended plans in the CAP?

Participant 3: Yeah, the plans are from the cities, so the actions are responsibility of the city and public sector ofcourse, some of the actions are taken by private sector and city does everything to make sure they cooperate and also and motivate them.

Chitransh Lot: The main sources of emissions is from transport as we all know, so what are the barriers specifically in this sector?

Participant 4: Sorry So so I just want to make an compliment on the previous comment by Sara, regarding different actors before we move on. I think it is very crucial aspect that Sara mentioned and I really want to stress on it, this CAP is most innovative of all where we are including other stakeholders. Private sector as Sara mentioned, citizens and as well as different territory authority and other rural areas around. This is the crucial part of the CAP, it is an inclusive plan considering all the relevant actors.

Chitransh Lot: Thank you! Coming back to my question, what are the challenges the transport sector face in the implementation of the plans?

Participant 5: It depends we have four group of actions in the CAP. The challenge is not only ours, so coordination with right authority is necessary, for example with the planning secretariat.

Chitransh Lot: What kind of change are we anticipating from the actions to mitigate emissions, is it more of a transformative change or more targeted towards changing people's behavior?

Participant 5: I guess both, the land use plan in CAP is focusing at not changing people's behavior particularly, but prioritizing the environmental consideration and connectivity of the cities and creating this concept of short commutes of 15-30 minutes time lapse within the city. Another is modal shift that is to increase the use of bikes, which I think demands more of a change in behavior of the people. Another challenge is to reduce emission from the freight and we don't have control over it, so we need to motivate the private sector and make sure they are on board with the agenda. So the challenge lies in creating the right incentive to promote change and it is also a sector that is marked by informal patterns and behaviors and so you find a lot of small owner of vehicle who don't have the opportunity to change the vehicle.

Chitransh Lot: So according to you, is building the infrastructure the main challenge or is it changing the people's behavior.

Participant 5: It's hard to say depends on the action, for the modal shift, yes it would be changing people's behavior. But for land use planning or freight, I think biggest challenge is not in terms of infrastructure, but in resources, and developing right policies to incentivize the change to happen. So, it is hard for example, with the freight sector it is always the risk that they go on strike and we may have the change something so it is really the negotiation with them, so that is the biggest challenge the behavior, small owner of truck wants to change but doesn't have the money or the opportunity to change. So, these little thins accounts for a lot.

Chitransh Lot: So one of the unique thing about C40 is its international aspect, so does Bogota uses the network to liaise with other cities in Latin America or beyond?

Participant 4: I can give some examples. We are currently working with Barcelona, and Bueno Aires, joining the technical cooperation program implemented by ICLEI on technical cooperation with regard to financing, positioning the international climate agenda and so on. We are also partners of a global research network which was funded by the German academic exchange services. We are working together with academic institution in Germany, Colombia and we are currently working on climate issues.

Participant 2: I think C40 is really useful for this kind of knowledge exchanges, for example, Covid-19 crisis, how London, Madrid, or Seoul were managing the transport sector, so C40 helps in arranging the contact with the cities and is very useful.

Chitransh Lot: That is good to hear. Now back on to the climate action plan, is there are monitoring system in place for climate action plans?

Participant 3: Yeah, we are working on that.

Chitransh Lot: Is it with C40 or are you are working on your own?

Participant 3: No we are working on our own using the tools or methodology provided by C40.

Chitransh Lot: Final question, what is the overall satisfaction of the municipality from the C40 membership?

Participant 3: Yeah as I mentioned, I already said it, it has been very helpful to have a very clear and transparent climate plan that can be deliver on time. And also all the help, the technical help and the financial help was very useful and not only that, all the declarations they had gave lot of strength to the plans. And with C40, they never stop, they are always sending new information or participating in programs they have. So have in this manner, they help and they leverage a lot in terms of implementation of plans. So, for me personally, the technical help have been very useful for climate action.

Participant 4: I would also add to that. C40 is massive, the degree of things they have to offer is sometimes very overwhelming, to keep track of. In that sense, the restructuring, they carry out of new business plan last year, it will aid in good overview and better understanding of what's out there. As Sara says, we try to make good use of everything we get and try to relish what we have in this new administration. So, we try to make sure that we are using the network optimally. But we are still in the process of making sense of everything that came before.

Chitransh Lot: I think Lina mentioned, Bogota has been part of C40 since the founding year of C40, and ever since and I know C40 has helped to put climate agenda in the context of Latin America, but in terms of measurable change, the process has been pretty slow so far, don't you feel that?

Participant 4: That's a tough question to answer. Sara I am going to say something so correct me later on. We have had some sort of climate action plan, not the same as we understand it now under the climate action planning framework. We had some climate plans which were released in PiFetro administration I believe in 2012. Then we had new climate action plan released in 2018 from the previous administration before Lopez, so there were actions planned out but the support was not the same from C40, and also the focus was more of climate risk mitigation and not so much on emissions reduction, which is the big focus with the new CAP. Another thing that is supporting the new CAP, is the new mandate from the legislation of the city which set us up for the plans to be implemented in the events of change in administration.

Appendix C

Qualitative Analysis

C.1 Governance typologies

Commanding cities
Typically use regulation and enforcement to deliver action. The role of private and other actors is often small.

Implementing cities
Commonly take action through the delivery of projects and programmes, often without the input of private and other actors.

Providing cities
Are characterised by a high level of control over service delivery, and are able to take action through this influence.

Legislating cities
Achieve progress on climate change by setting policy and legislation that requires others to act.

Collaborating cities
Commonly act in partnership with other actors to leverage their respective powers.

Facilitating cities
Have limited power to take action directly, instead focusing on creating an attractive environment for others to act.

Figure C-1: *C40 cities categorised on their governance typologies [10]*

C.2 Mitigation projects of cases

	Bogotá	Copenhagen
-Mitigation actions		
	-Sustainable mobility - Fuel substitution	-Environmental zone in the Inner Harbour
	-Define higher standards for new construction	-Afforestation on water catchment areas
	-Energy saving and efficiency	-Efficient operation of district heating
	-Transportation-oriented development	-Reducing emissions from non-road vehicles
	-Transportation management of freight	-Establishing a biogass production based on organic waste
	-Implement the sustainable guidelines guides of the Bogota Ecourbanism and Sustainable Construction Policy, for urban, rural and building areas, with regard to the thematic axis materials and waste	-Energy leap
	-Formulate and implement a new model for the use of organic waste and recyclable material, based on the circular economy approach.	-Energy efficiency in municipal buildings
	-Improve the current final disposal of waste and evaluate and implement alternatives for thermal treatment and / or similar with power generation.	-RE-based town gas system
	-Implement a district strategy for green growth with a focus on environmental sustainability and innovation	-Energy efficiency in municipal buildings
	-Expand the coverage of the city's wastewater that is treated in a centralized plant with advanced treatment technology	-Energy efficiency in municipal buildings
	-Thermal district heating	-Shore power for cruise ships
	-Formulation and implementation of decentralisation in energy infrastructure	-Urban Renewal
	-Sustainable Mobility - Modal Shift	-Environmental zone in the Inner Harbour
		-Reducing emissions from non-road vehicles
		-Energy leap

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Bogotá	Copenhagen
	-Energy efficiency in public housing
	-Urban Renewal
	-Efficient operation of district heating
	-Shore power for cruise ships
	-Energy leap
	-Reducing emissions from non-road vehicles
	-Energy efficiency in public housing
	-Carbon neutral wastewater treatment
	-Establishing a biogass production based on organic waste
	-Energy leap
	-Wind power expansion
	-Shore power for cruise ships
	-Efficient operation of district heating
	-Fuel switch in public vehicles
	-Energy efficiency in municipal buildings
	-Reducing emissions from non-road vehicles
	-Afforestation
	-Establishing a biogass production based on organic waste
	-Energy efficiency in municipal buildings
	-Afforestation
	-Efficient operation of district heating
	-Fuel switch in public vehicles
	-Energy efficiency in municipal buildings
	-Energy efficiency in public housing

Table C-1 continued from previous page

Bogotá	Copenhagen
	-Energy efficiency in public housing
	-Shore power for cruise ships
	-Efficient operation of district heating
	-LED street lighting
	-Reducing emissions from non-road vehicles
	-Environmental zone in the 'Inner Harbour'
	-Fuel switch in public vehicles
	-Energy efficiency in public housing
	-Reducing emissions from non-road vehicles
	-Efficient operation of district heating
	-PV Strategy
	-Zero emission bus transit in 2025
	-District cooling
	-Energy leap