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Abstract

With the transition to carbon-free economy, concerns have grown about the "green divide" – the separation of society into different social groups whose socioeconomic status determines one's well-being from climate change impacts. Studies in environmental justice concur that the adverse effects of urban climate change are disproportionately greater for the demographically vulnerable populations, such as the elderly, the children, and the socially marginalized. Yet, little is known about how these social groups contribute to urban climate change policies. Accounting for local climate risks and the presence of national adaptation schemes, this study examines whether the implementation of adaptation policies in the 902 European cities is influenced by the proportion of these vulnerable groups. Our results show a positive and significant association between the proportion of elderly citizens and adaptation policies among these European cities. The result of this study offers local level empirical evidence to the climate justice discussion and suggests that the adaptation policies adopted by these European cities are working to ameliorate environmental injustice faced by the older and weaker social groups.

Keyword: environmental justice; climate justice; elderly citizens; urban climate policy; local climate risk; adaptation policies

1. Introduction

Heat waves in the summer of 2003 killed about 70,000 additional Europeans (more than 15,000 people in France, 9,000 in Italy, 7,000 in Germany, 6,000 in Spain, 2,000 in England, and 500 in Netherlands) (J.-M. Robine et al., 2008), stressing the need to consider adaptation in the planning of sustainable cities (Sahay, 2019). Among the death toll, mortality rates increased with age. A study found that "the mortality trajectories by age are exponential for both sexes (J. M. Robine, Michel, & Herrmann, 2012)." Along with poverty, social isolation, and minority ethnicity, age is a characteristic that contributes to being most vulnerable to climate extremes. The current COVID-19 pandemic has proven itself to be disproportionately more harmful to these already vulnerable groups (Koff & Williams, 2020) and the pandemic is expected to collide with climate extremes, which will expose the elderly to even greater risks. This uneven distribution of risk and vulnerability makes it more important to keep climate justice at the forefront and center of global discussions.

Climate justice considers the socio-economic equity aspect of those that are the most vulnerable but the least accountable. The logic of climate justice is in fact quite straightforward: individuals who have limited opportunities or resources are more likely to be affected by climate change and, thus, it is the responsibility of society to ensure that valuable resources are equitably allocated amongst its members (Barrett, 2013; Shi et al., 2016). Although there is a growing interest in the importance of social equity for climate change and green divide at the national and urban levels (Holland, 2017; Kremer, Haase, & Haase, 2019; Schrock, Bassett, & Green, 2015),

little is known of the role of vulnerable groups in climate justice and of the potential relationship between climate justice and adaptation policy.

The goals of this paper are to answer some of following questions and provide a better understanding of the relationship between environmental justice and urban climate change policies: how is socioeconomic status, such as age, income and education, associated with climate change policies? If certain groups or individuals are more affected by this green divide, what could be done to reduce this disparity? What does it mean for a city to adopt an urban climate change policy that is specifically concerned with environmental justice for the vulnerable social groups? To be more specific, the main research question of this study is: What is the role of vulnerable social groups on the adoption of adaptation policies of cities?

This study will first look at the environmental justice literature to understand how the impacts of climate change is disproportionately more adverse in some social groups and then presents the hypotheses. We follow up by describing the methodology and dataset used to answer our research question and hypotheses. In the results and analysis section, we examine the findings and discuss their overall implications and significance. Finally, we discuss the limitation of our study and conclude with suggestions for future studies in climate change and environmental justice.

2.1 Environmental Justice and Urban Adaptation

Despite the surge of literature on urban climate governance in the last ten years, emphasis has mainly been placed on the role that cities have crafted for themselves in governing both mitigation and adaptation policies, while little focus has been given to justice related questions

(Bulkeley, Carmin, Broto, Edwards, & Fuller, 2013; Lee, Yang, & Blok, 2020). However, debate on climate justice has increasingly become a concern within the urban context. As the role of cities in addressing climate change has become more commonly accepted, numerous strands of academic literature have intertwined, creating a fusion between climate action and justice debate (Hughes & Hoffmann, 2020; Jenkins, 2018). Initially, much of the debate was found within the international arena, for example, concerned mainly with the labor movement and energy transitions (McCauley & Heffron, 2018). But local concerns over justice have slowly emerged within the urban context as well (Bulkeley et al., 2013).

This local focus has centered on justice related to urban transitions (Hughes & Hoffmann, 2020), agendas for climate change ethics and justice (Byskov et al., 2019), social dimensions of urban adaptation in terms of equity and justice (Shi et al., 2016), and interplay with other sustainable and smart city approaches (Kremer et al., 2019). From a mitigation perspective, it has been argued that the efforts to address the impacts of climate change generally benefit the industries and are geared toward policies that are intended to reduce greenhouse gas (GHG) emissions, which is why the need for energy justice has been deemed important (Heffron & McCauley, 2018). For example, the transition to low-carbon economy has caused traditional-style industries and jobs to fall behind, often leading to corporate restructuring and massive layoffs for those who are ill-prepared for the new economy (Heffron & McCauley, 2018). Meanwhile, from an adaptation perspective, the main focus has been on the effects of climate related environmental risks that can have greater negative impacts on vulnerable communities and population, which has also been suggested as the cause for reproducing and worsening the social and environmental inequalities (Holland, 2017).

Underlying these arguments are three distinct ways of conceptualizing climate justice, as the definition has expanded from an outcome-based analysis to a more reflective analysis of historical developments and power (Bulkeley et al., 2013; Holland, 2017). First, drawing on the environmental justice literature, *distributive justice* is framed in terms of fair and equal distribution of environmental goods and benefits to all members of society (Hughes & Hoffmann, 2020). Here, the chief inquiries explore who the recipients are and how environmental justice will be distributed. In the context of adaptation, this means identifying who is vulnerable and how the benefits of adaptation will be shared. Next, *procedural justice* recognizes the notion that not all members of a society engage in decision-making, and there is a need to examine the process of decision-making to understand the fairness of them (Hughes & Hoffmann, 2020). In the adaptation context, this means examining who participates in the formal and informal institutional process of shaping the policy and the politics of adaptation. Adaptation planning takes many forms, from formal institutional processes to autonomous adaptation through networks and individual action. Focus on procedural justice shifts the attention from the outcome to the process of decision-making, which permits scholars to explore how certain social groups are marginalized or overlooked while others are empowered at their expense. Finally, *justice as recognition* further extends the concept of justice by recognizing the needs of plurality from the start, accepting that cultural and institutional norms and practices can inherently give unequal representation to certain groups (Hughes & Hoffmann, 2020). In the context of adaptation, this means identifying the historical development trajectories that may have contributed to injustices, which have made some groups in society more vulnerable.

As the focus of this paper is on the association of adaptation policies and disadvantaged groups, all three frameworks on environmental justice are relevant. From the theory perspective, the most relevant questions here are who benefits from the adaptation policies, how the adaptation planning process and measures can identify and prevent current inequalities and injustices from being reinforced, and how to address the potential future climate risks (Byskov et al., 2019). Equally important, it is crucial to examine whether vulnerable populations have the political power or capability to influence adaptation decisions in the first place, as this may open up opportunities to overcome inequalities and injustice they face (Holland, 2017). Therefore, extending the participation in adaptation planning by these groups becomes the key in ensuring that justice concerns are addressed (Shi et al., 2016). The current empirical literature shows that the decision regarding the participation in adaptation planning is determined by the public sector both in terms of who participates (Shi et al., 2016) and who is responsible for steering the tools and resources of the public sector (Klein et al., 2018).

Although much of the discussion so far has been theoretical, we have identified two streams of empirical literature regarding justice. The first is the emergence of literature of individual case studies, which often highlight the dynamics of vulnerability and the manifestation of injustice during the adaptation planning process or outcomes in one or selective cities. The second is a smaller body of work that has attempted to capture a wider coverage of empirical developments by collecting a larger sample of cities.

The first stream of empirical cases has highlighted the historical background which influences the current adaptation practices that exacerbate injustice (Bordner, Ferguson, & Ortolano, 2020),

mainly due to the complexities and tensions involved between local-level institutions and vulnerable groups and the degree to which participation is restricted in the decision-making process (Omukuti, 2020). Also, studies have examined how different values contribute to the impressions of fairness (Graham, Barnett, Mortreux, Hurlimann, & Fincher, 2018) and the perceptions of threat (Jurjonas, Seekamp, Rivers III, & Cutts, 2020). The low level of engagement by the vulnerable groups and the little influence they have over the adaptation decision has likely made the situation worse (McManus, Shrestha, & Yoo, 2014). In order to improve the situation, a number of solutions has been proposed, including measures to increase inclusive involvement by these groups (Nurhidayah & McIlgorm, 2019) and uncovering the underlying assumptions embedded in the climate discussions (Jurjonas et al., 2020).

The second stream of literature attempts to build a bigger picture by examining a wider empirical sample in order to provide a more comprehensive view of how extensive justice and equity issues are taken into account. Bulkeley and authors (2013), drawing on a database of 100 cities, show that the subjects regarding procedural justice were frequently brought up in the policy documents of cities in the Global South. Fitzgibbons and Mitchell (2019) examine 31 city-level strategies to find that existing adaptation strategies with regard to equality and justice are fragmentary and patchy at best, and some strategies contain measures that may even contribute to further inequity.

2.2. Adaptation policies and vulnerable social groups

In order to understand the role of vulnerable social groups on the adoption of adaptation policies, it is also necessary to explore the development of adaptation policies and what the main drivers are. In this paper, we consider the three types of drivers that are identified in the literature, namely the existence of vulnerability, exposure to climate hazards and institutionalization of political processes.

First, the existing or threat of future vulnerability, such as heat stress risks in urban environment, has been cited as a reason for pursuing adaptation (Hatvani-Kovacs, Belusko, Skinner, Pockett, & Boland, 2016). Research on vulnerable groups has grown dramatically and studies have shown that the level of vulnerability to climate change results from a range of sociodemographic, economic, historic, and political factors, all of which operate at multiple scales (Thomas et al., 2019). Old age is often considered a critical factor of vulnerability for the general population (Carter et al., 2016; Wolf, Adger, Lorenzoni, Abrahamson, & Raine, 2010). Vulnerability to heat, for example, emerges from multiple factors, including physiological but also from social and behavioral limitations due to low awareness or perception of risk (Hansen et al., 2011). Likewise, children are often considered to be vulnerable to climate change impacts, as they are more likely to be casualties of extreme weather events, water and sanitation-related illnesses, vector-borne and infectious diseases, respiratory illnesses, heat stress or other types of injury (Bartlett, 2008), while also having higher risk of malnutrition (Davenport, Grace, Funk, & Shukla, 2017). While children living in urban areas are generally considered to be better off compared to their rural counterparts, urban poverty is a significant phenomenon worldwide, exposing city children to climate change threats as well (Bartlett, 2008).

While age and other physiological characteristics can increase vulnerability, it is also clear that there are a number of non-climatic drivers for vulnerability (Räsänen et al., 2016). A good example is when certain groups are excluded from the decision-making process, they are more likely to experience injustices and become more vulnerable (Tschakert, van Oort, St. Clair, & LaMadrid, 2013). In the majority of the studies discussed above, the term vulnerable group refers to groups that are marginalized and exposed to vulnerabilities due to physical characteristics that are directly affected by climate change impacts, but the term does not necessarily indicate the exclusion from the decision-making process. It is important to keep this distinction in mind. Studies have also shown that vulnerable groups can be socially marginalized based on ethnic and racial background and other cultural, religious and linguistic upbringing (Shi et al., 2016). Few studies which specifically look at the U.S. context have concluded that predominantly black, low-income and indigenous communities often face disproportionately high level of exposure to environmental pollution and pollutants (Brulle & Pellow, 2006; Mohai, Pellow, & Roberts, 2009). Immigrant status has often been considered a source of vulnerability, owing to weaker social networks and difficulties integrating into society (Carter et al., 2016; Rød et al., 2012).

The literature discusses the link between vulnerability and adoption of adaptation policies (Berndtsson et al., 2019; Hunt & Watkiss, 2011), and since the socially marginalized groups are more likely to be affected by the negative impacts of climate change, they are more likely to support adaptation policies. Therefore, this leads us to pose our first hypotheses:

H 1.1. Cities with higher proportion of older population are more likely to adopt adaptation policies.

H 1.2. Cities with higher proportion of children are more likely to adopt adaptation policies.

H 1.3. Cities with higher proportion of immigrant populations are more likely to adopt adaptation policies.

Second, there are also studies that show that exposure to potential climate impacts can lead to the adoption of policies to mitigate their effects. Studies have shown that coastal cities that are exposed to greater impact of climate change, such as New York City, Hamburg or Rotterdam, have been advancing rapidly with their adaptation policies (Doberstein, Tadgell, & Rutledge, 2020; Huang-Lachmann & Lovett, 2016). Among the impacts of climate change, the exposure to sea level rise has been identified as the main cause (Ward, Pauw, van Buuren, & Marfai, 2013). The sea-level rise is a slowly emerging threat but it has been linked with other climate extremes, such hurricanes, which can exacerbate their impacts (Forzieri et al., 2016; Giardino, Nederhoff, & Vousdoukas, 2018; Solecki, Leichenko, & O'Brien, 2011). In addition, increasing climate-change-induced urban floods also invite effective adaptation measures such as low impact development techniques (Pour, Abd Wahab, Shahid, & Dewan, 2020). Given that exposure to direct climate impacts can have costly consequences, we hypothesize that:

H 2.1 Cities experiencing climate extremes are more likely to adopt adaptation policies.

H 2.2 Cities exposed to climate hazards are more likely to adopt adaptation policies.

Third, the scale of institutional developments can also affect the adoption of adaptation policies of a city as adaptation has been shown to be a multi-level governance structure (Hanssen,

Mydske, & Dahle, 2013; Nalau, Preston, & Maloney, 2015). There is evidence of two types of development. First, national-level adaptation can contribute to the adoption of adaptation policies at the city-level (Lee et al., 2020). On the other hand, studies have shown that if national policy has a strong sectoral focus, then it may not influence the city level significantly (Kythreotis, Jonas, Mercer, & Marsden, 2020). In the absence of strong national level steering, participation in policy networks can influence the uptake of adaptation policies (Juhola & Westerhoff, 2011; Lee, 2018), while being part of more than one networks can lead to being more advanced in adaptation, (Heikkinen, Karimo, Klein, Juhola, & Ylä-Anttila, 2020). Thus, given this, we hypothesize as follows:

H 3.1. Cities in countries with a national adaptation strategy are more likely to adopt adaptation policies

H 3.2. Cities involved in climate change networks are more likely to adopt adaptation policies.

3. Data and Methodology

To test our hypotheses on the adoption of urban climate adaptation policy, we use a quantitative method that is based on the multilevel logistic regression analyses. The attributes of the cities are generally affected by those of the countries and multilevel modeling is a way of analyzing the nested characteristics of a city within a country. We measured the effects of independent variables on the adoption of adaptation policy by utilising logistic regression analysis.

Specifically, we used the multilevel logistic regression using both city-level and country-level data.

Data source for the analysis comes from the database of Climate ADAPT urban adaptation map (https://climate-adapt.eea.europa.eu/knowledge/tools/urban-adaptation). This database provides current and future climate adaptation hazards and policy of European cities. Climate ADAPT is partnered with the European Commission and the European Environmental Agency to collate the spatial distribution data of urban climate vulnerability and adaptation planning of 902 cities from 30 European countries as of 2019.

Our key dependent variable is whether a city has adopted an urban adaptation policy. This policy reflects a city's independent adaptation activity that is distinct from a national policy. It is a binary variable; city with an independent adaptation policy is assigned the value of 1 and those with none is assigned the value of 0. Out of 902 cities, 218 cities have adaptation policies (24.17%); 684 cities have none (75.83%).

Our model examines the association between the six sets of variables and the adoption of urban climate adaptation policy. The six sets of variables consist of city-level data including social vulnerability (the ratio of the old, children, and immigrants), climate extreme vulnerability (heat, temperature, precipitation, forest fire), land cover and exposure to hazards (green space, sealed surface, flood, coastal cities), cities' climate change network membership (the Covenant of Mayors, and 100 Resilient Cities), economic variable (local total Gross Domestic Product) and a country-level climate adaptation policy by the national government (national adaptation policy, assessment, and monitoring).

The main independent variables measure the level of the city's demographic vulnerability to climate risks. The first variable is the percentage of people 75 years old or older in the population. A higher ratio of elderly population means the city has higher possibility of being vulnerable to climate risks, placing the city government to be responsive to adaptation policy. EU has set 75 years old or older as a socially vulnerable indicator in the Urban Audit database (EEA, 2018). Another demographic variable we consider is the percentage of children under 5 in the population. Similar to the elderly population, a higher ratio of children can be related to higher possibility of vulnerability. Last variable for vulnerability is the percentage of people who are born in another country.

For the second set of control variables, we use the climate vulnerability indicators data because a city's adaptation policy can be the result of responding to existing climate extremes. Variables for climate indicators are as follows: average number of hot summer days (temperature max>35℃) per year between 1987 and 2016, average number of forest fire danger between 1981 and 2010, observed trends in maximum annual five-day consecutive precipitation in summer between 1960 and 2015, observed trends in maximum annual five-day consecutive precipitation in winter between 1960 and 2015, and observed trend in frequency of meteorological droughts, dry weather patterns dominating an area which is measured by combining Standard Precipitation Index, Standard Precipitation Evapotranspiration Index, and Reconnaissance Drought Index, between 1950 and 2012.These climate indicators indicate the historical trends or the average climate risk events that might influence the city's adaptation policy. For instance, temperature exceeds 35℃ is a reference point to negative health impacts (40% of deaths associated with heat on hot days) (EEA, 2018).

In addition to climate indicators, we control for several other variables that include land cover and exposure to hazards, as they help explain the usage of urban space. Usage of urban space including public and green space is a factor that can fundamentally change the landscape of a city, making it more or less vulnerable to climate risks and environmental damages (Foshag et al., 2020). The data consists of the rank of each city in Europe measured by the percentage of green space in the Urban Morphological Zone (UMZ), the change in percentage of sealed surface in the city, and lastly, the percentage of land used in the UMZ which was exposed to at least 1 case of river flooding in the last 100 years and is at risk of being flooded until the year 2080s when assuming the same land use trend. This is calculated by the JRC Lisflood model. We have also included data from Eurostat to indicate whether cities are located in the coastlines or are inland, as coastal cities may be exposed to greater risk from sea-level rising. These variables about land cover and exposure to hazards demonstrate any potential climate-related threat that a city might face.

We also controlled for the economic performance of the cities as wealthy cities are thought to be more likely to engage in climate change agenda as they have greater capacity to take action and bigger interests to protect (Lee & Hughes, 2017). We controlled for other adaptation policies that a city might be participating in. Participation and being a member of a network for urban climate change policy is known to significantly affect the trajectory of a city's response to climate change (Heffron & McCauley, 2018). We used two dummy variables: whether a city is a signatory on adaptation to the Covenant of Mayors on climate and energy and whether a city is a member of the 100 Resilient Cities Initiative. A city that is a signatory or a member is assigned the value of 1 and a city that is not a signatory or a member is assigned the value of 0. This last controlling measures indicate a city's tendency toward urban climate change policies.

Lastly, based on the multilevel climate governance literature (Lee & Koski, 2015; Reckien et al., 2018), we included the national-level climate policy variables in our models. Cities in a state with a national adaptation policy, an assessment method (impacts and vulnerability), and a monitoring system are more likely to adopt an urban adaptation policy as well (Lee et al., 2020).

Table 1. Variable description and descriptive statistics

Variables	Brief Description and Operation	Mean(S.D.)	Min-Max
Dependent Variable			
Adaptation Policy	City with adaptation policy (1=policy: 218 cities; 0=no policy: 684 cities)	.24 (.42)	0-1
Social Vulnerability Variables			
The Old	People 75years old or older (%)	7.13 (1.64)	2.1-9.9
Children	Children under 5(%)	5.40 (1.12)	0.6-9.7
Born Abroad	People born in another country (%)	8.50 (7.29)	0-45.7
Climate Indicator Variables			
Hot Summer	Average number of annual hot summer days (Tmax>35℃) (1987-2016)	1.70 (5.91)	0-56
Forest Fire	Average forest fire danger (1981-2010)	2.77 (2.75)	0.07-58
Summer Precipitation	Observed trends in maximum annual five-day consecutive precipitation in summer (1960-2015) [mm/decade]	.84 (1.08)	-2.7-2.75
Winter Precipitation	Observed trends in maximum annual five-day consecutive precipitation in winter (1960-2015) [mm/decade]	-.40 (3.37)	-9.07-78
Droughts	Observed trends in frequency of meteorological droughts (1950-2012) [events/decade]	.08 (.61)	-1.06-17
Land and Hazard Variables			
Greenspace	Percentage of green space in Urban Morphological Zone	.02 (.02)	-.02 (.06)

Sealed Surface	Change in % sealed surface in the city area	.02 (.01)	-.01 (.06)
Flood	Percentage of land uses in UMZ potentially exposed to 1 in 100 years river flooding, currently and in the 2080s, assuming the same land use	8.4 (8.3)	.004 (65)
Coastal Cities	A coastal city is defined based on whether city has a sea border (or located on a coastline) (0=inland city; 1=coastal city; 2=over 50% of population living within 50km of coastline)	.45 (.02)	0-2
Economic Variable			
City GDP	Cities' year 2014 total Gross Domestic Product USD (logged)	23.65 (.04)	23.58-23.72
Urban Adaptation Network Activities			
Covenant of Mayors	A signatory on adaptation to the Covenant of Mayors on Climate and Energy (1=a signatory: ## cities; 0=not a signatory: ## cities)	.11 (.31)	0-1
100 Resilient Cities Initiative	A member of the 100 Resilient Cities initiative (1=a member: ## cities; 0=not a member: ## cities)	.04 (.21)	0-1
National climate adaptation policies			
National adaptation policy	National adaptation policy adopted (1); not adopted (0) ## countries)	.76 (.42)	0-1
National adaptation assessment	Impacts, vulnerability and adaptation assessments completed (1) being developed (0)	.92 (.27)	0-1
National adaptation monitoring	Monitoring, Indicators, Methodologies Established (1); or not (0)	.80 (.39)	0-1

4. Results

We find the end results of our analysis promising. Our analytic strategy was to specify our models to reflect the different sets of control variables we wanted to verify. The results of Model 1 which solely included the socially vulnerable groups (H1.1-1.3, i.e., the old, children and born abroad) have confirmed the statistically significant and positive association between the elderly and adaptation policies. As can be anticipated, the higher ratio of elderly population means that a larger number of constituents are exposed to climate risks, which translates to greater pressure and motivation for city governments to be responsive to adaptation policy. The results are not as significant for cities with a greater proportion of other groups. Despite comprising substantial portion of the vulnerable groups, children and immigrant groups did not have much effect on city's adoption of adaptation policies. The reasoning may be that although children are exposed to the same risks as the elderly, they are viewed as surrogates of their parents and do not have much say in the policy decision process, and therefore not considered important constituents. The same could be said of the immigrants, as many have yet to become official members of the formal political system that allow them to express opinions and participate in the political process of determination.

Table 2. Multilevel analysis of the factors that drive urban climate adaptation plan

	Model 1: Social Vulnerability	**Model 2: Climate Hazards**	**Model 3: City-level only**	**Model 4: City & Country-level**
City-Level Variables				
The Old	.31 (.11)**		.49 (.16)**	.44 (.16)**

Children	-.03 (.16)		.02 (.24)	-.02 (.24)
Born Abroad	.03 (.02)		-.02 (.03)	-.03 (.03)
Hot Summer		-05 (.04)	-.11 (.08)	-.12 (.07)
Forest Fire		.01 (.06)	.10 (.16)	.09 (.16)
Summer Precipitation		-.12 (.21)	-.55 (.33) †	-.60 (.33) †
Winter Precipitation		-.04 (.09)	-.002 (.12)	-.03 (.12)
Drought		-.88 (.76)	-.71 (1.00)	-.70 (1.03)
Greenspace		.02 (.015)	.02 (.02)	.02 (.02)
Sealed Surface		.02 (.01) †	.03 (.018)	.03 (.02)
Flood		-.26 (.016) †	-.0009 (.02)	.001 (.02)
Coastal Cities		.37 (.29)	-.10 (.38)	-.07 (.38)
Covenant of Mayors			1.33 (.53)*	1.36 (.53)*
100 Resilient Cities Initiative			1.72 (1.02) †	1.69 (1.03)
Gross Domestic Product (cities)			.40 (.19)*	.39 (.19)*
Country-Level Variables				
National adaptation policy				3.07 (1.53)*
National adaptation assessment				.20 (1.60)
National adaptation monitoring				-1.19 (1.22)
Random effect parameter (SD)	2.24 (.62)	1.49 (.40)	2.25 (.72)	1.85 (.63)
N (country)	621(23)	572 (27)	389 (22)	389 (22)

Note: Numbers are regression analysis coefficients, and standard errors in parentheses. Levels of significance are denoted as follows **$p < 0.01$; *$p < 0.05$; †$p < 0.10$.

Meanwhile, Model 2, to test H 2.1 and H 2.2, solely consists of climate hazard variables that are generally considered as the main motivators for cities to adopt any form of climate change policy. However, except for the sealed surface area and area exposed to flooding, which are slightly statistically significant ($p < 0.10$), none of the climate indicator variables had any association with city's adaptation policies. Contrary to conventional notion that local climate extremes or climate hazards would drive authorities to eminently respond to such risks, city governments seem to be far less responsive to these climate extremes. Therefore, our initial H 2.1 and H 2.2 are not supported by the results of the analysis. This suggests that the deliberation process involved in the decision of city's adaptation policies is more likely driven by political factor than the reality of climate hazard that is based on scientific data or historic observations. Given limited resources, it is possible that climate change may not be considered essential or top priority to the city government's agenda, which lends additional support to earlier argument that only when its political constituents are harmed, such as the elderly, then are cities willing to take appropriate measures.

Results in both city-level (Model 3) only and city and national-level (Model 4), to test H 3.1 and H 3.2, show that the presence of older vulnerable group has a significant impact on the adoption of adaptation policies in the European cities. Even after controlling for the geographical and topographical exposure to climate change risks, there is unmistakable evidence that cities with greater proportion of elderly citizens with the age over 75 and over are more likely to have adaptation policies. Results also show that cities with higher GDP have statistical significance

with the adoption of adaptation policies, as wealth is a good indicator of cities' potential to deal with climate change. However, even when considering the economic wealth of the cities, the effect of elderly citizen in our model remained unchanged. Moreover, both Model 3 and Model 4 show that the Covenant of Mayors membership has a statistically significant positive association with city's adaptation policies, which support our H 3.2. Covenant of Mayors has traditionally been concerned with climate change adaptation policies and, therefore, cities with CoM membership are more likely to undertake climate adaptation policies. Cities can learn from each other about other cities' advanced adaptation policies through these close-knitted collaborative networks and joining such international networks may educate leaders of the plight of the vulnerable groups and the importance of restoring social justice.

Finally, national-level variables include the distinct stages of national adaptation policy (i.e., plan, assessment and monitoring) into Model 4 and except for the national adaptation policy, the other stages of national adaptation are not statistically significant with city's adaptation policies. This suggests that there is a clear linkage between the national and city adaptation policy but less so with the national adaptation assessment or monitoring system.

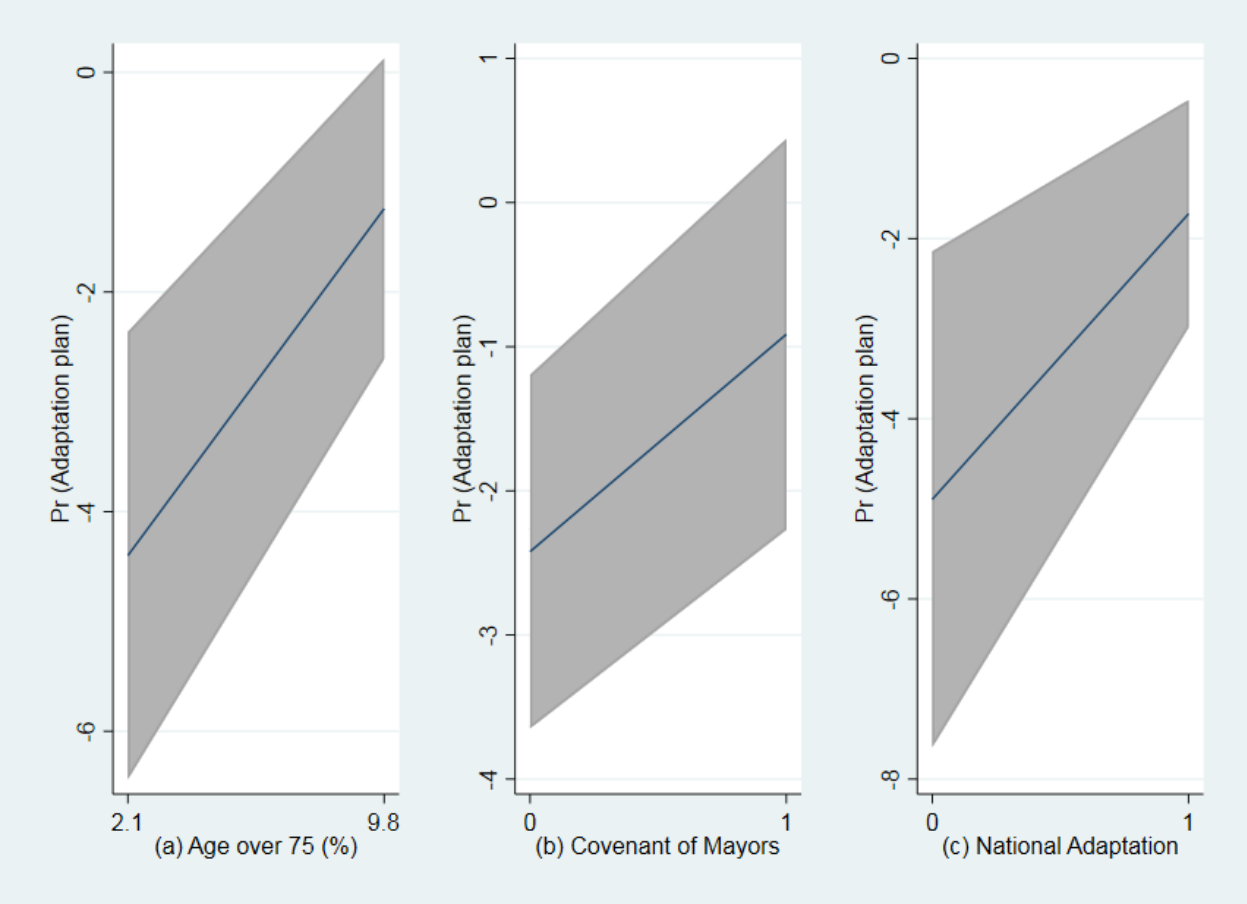

Figure 1. Predictive Probability of Logit Analysis with Key Variables

To give a better understanding of the association between the key independent variables and urban climate adaptation policy, Figure 1 shows the probability of having an adaptation policy using a predictive probability logit model for (a) the percentage of age over 75; (b) membership in the Covenant of Mayors; and (c) the presence of national climate adaptation policy. Cities with 2.1% of the population with age over 75 only have a 2.6% probability of having an urban adaptation policy, while cities with 9.8 % population aged 75 and over are likely to have an adaptation policy with a probability of 49.2%, with all other covariates fixed at the means. In the case of membership in the Covenant of Mayor, non-member cities have a 22.2% probability of having a climate adaptation policy, while member cities show a higher probability of 36%.

Finally, the presence of national climate adaptation policy is also linked with a seven-fold higher probability of adopting an urban adaptation policy, 31.2% compared to 4.3% probability for cities without a national policy.

5. Discussion

Climate justice literature has suggested that climate change can have a greater impact on the vulnerable groups (Holland, 2017; Thomas et al., 2019), whose participation in the decision-making process is severely limited (Tschakert et al., 2013). This study examines the empirical interactions of climate justice and adaptation policies in the urban setting. Our research theorized the relationship between the socially weak groups – the old, the children and the immigrants – and climate change adaptation policy. Our empirical analysis of 902 European cities, using a multilevel modeling, suggests that the cities with higher ratio of senior population are more likely to adopt climate change adaptation policy.

This link between senior population and adoption of adaptation may be due to the fact that the elderly are more vulnerable to extreme weather conditions, especially heatwaves and anomaly long summer nights. Public cooling centers, for example, to prevent the health impacts of heat waves (such as hyperthermia) are active urban climate adaptation measure that is extremely helpful for the elderly and the vulnerable to get by during extreme weather conditions. European cities cater to these specific threats by finding proactive and precautionary measures from the adaptation domain to accommodate the needs of the socially vulnerable groups.

However, it is also important to keep in mind that public adaptation planning is only one part of adaptation, especially when it comes to engaging with vulnerable groups. This is an area where many third sector and voluntary organizations work, and their contributions and networks can be used for adaptation and these may go unnoticed and unaccounted for in the public sector planning. It would therefore be pertinent to examine whether the existence of these types of networks and their social capital could be better included as variables to predict the of urban climate adaptation.

Cities pursue certain policies with specific stakeholders in mind and adopting urban climate adaptation policies with concern for certain vulnerable groups resonates the concept of distributive justice that emphasizes fair distribution of environmental goods to all (and particularly the vulnerable) members of society. If cities with large population of the elderly are not engaging in adaptation, then it may mean that the benefits of adaptation are not shared equally by their members. However, as shown in the result of our study, if cities with a higher proportion of elderly population is linked with a higher rate of adaptation policy, this may suggest that adaptation benefits are more equally shared, thereby, positively contributing to the distributive justice aspect of adaptation policy.

Moreover, the findings of this study have reasserted that adaptation policies have less to do with local climate risks and city governments seem to be far less responsive to these climate extremes. Even if cities are exposed to extreme climate events, such as sea-level rising or flooding, cities do not resort to adaptation policies to respond to these local risks. It might be that cities are maintaining and expending their mitigation policies or adaptation policies are driven by other

factors, such as political deliberations or available slack resources. Our results also show that cities with higher GDP are more likely to adopt adaptation policies. This is troubling in some ways, as this indicates that environmental justice may be harder to achieve in less affluent cities and the socially vulnerable groups may be exposed to greater threats in these cities. Our study also sheds more light on whether the existence of a national-level policy influences the adoption of city level adaptation policy. Our findings seem to suggest strongly that this is the case, but interestingly the advancement of the national policy seems to have little impact. Similarly to Kythreotis and authors (2020), we question the urban scale and its autonomy in governing climate adaptation responses.

More widely speaking, our research contributes in several ways to our understanding of adaptation policy in the European cities and suggest a potential association between social vulnerability and environmental justice. First of all, unlike conventional studies that link climatic, geographical and topographical susceptibilities as the major motivation for adaptation actions, the results of this investigation show that the presence of the old and the vulnerable population have a greater impact on climate adaptation policies. Second, as evidenced in this study, the relationship between urban adaptation planning and socially vulnerable groups would likely inspire the scholars and practitioners alike to critically examine methods to elevate and promote environmental justice and social equity into a defining theme within the adaptation policy. Similarly to Zaidi and Pelling (2015), these findings support the need to examine the institutional structure that creates vulnerability and can be used to alleviate it. This focus on procedural justice stresses the need to develop more inclusive processes and participatory techniques during the adaptation planning. These new findings would help cities to become more

cognizant of the impacts of climate disasters that are less visible to the eyes and more deeply rooted on the social and historical disparities – especially resulting from old age – so that cities may better prepare themselves against future disasters while upholding environmental and social justice.

However, the measure that appears to be most clearly associated with the issues of environmental justice and social equity would be whether cities have considered procedural justice when adopting urban adaptation policies. If the elderly and vulnerable groups are included and shape the cities' adaptation policies, this would likely be a direct reflection of the consideration of environmental justice and social equity. Unfortunately, we were not able to incorporate a good operational measure to identify environmental justice and social equity measures for the cities included in our study. Although cities are making environmental justice a growing priority, there does not appear to be an acceptable empirical measurement to examine the relationship between the protection of the socially vulnerable groups and the general concept of environmental justice. This could be an area where future research would be helpful.

6. Conclusion

Scholars urge attention to fair and equitable process when transitioning to the post-carbon society, whereby age, race, gender and social economic status are taken into full consideration not only in terms of mitigation but also in terms of adaptation (Hughes & Hoffmann, 2020). This requires acknowledging that climate risks are unevenly distributed and there is a need to pay attention to the procedural justice and justice as recognition, which requires identifying

vulnerable communities to climate change related risks and empowering those communities to intervene in the political decision-making process, either through issue generating or alliance with stakeholders. This could provide opportunities to reduce environmental inequities that can be expected from adopting adaptation policies (Holland, 2017).

Moreover, measures to increase inclusion, such as participation and co-ownership, need to be at the forefront of the discussion, as these issues are too often missing or underrepresented during the implementation (Kremer et al., 2019). There have been transdisciplinary attempts to enhance social justice by increasing relevant stakeholder participation when designing open public spaces and this participation have led to practicality and improved design solutions (Foshag et al., 2020), but the question still remains whether greater environmental justice has been achieved. Others have suggested integrating a broader engagement by different stakeholders and policy makers when measuring environmental impact indicators, to make sure that everyone's interests are properly represented during the planning of adaptation policies with response to heatwaves (Hatvani-Kovacs et al., 2016). Although climate adaptation policy requires deliberate leadership for its successful planning and implementation to achieve a more effective and meaningful integrated outcome that is also socially and environmentally just, it is important to include the vulnerable groups that are the most affected from the beginning of the discussion.

Concerns about the receptivity of future climate adaptation programs and policies have given rise to a more people-centric approach with a focus on the needs of the people when considering the justice aspect of environmental policies more widely. Some have suggested the inclusion of

sustainability efforts and other equity aspects when implementing the policies from the onset during in the planning phase. This represents a shift from traditional planning approaches.

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