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How do urban characteristics affect climate change mitigation policies?

Hidemichi Fujii [a], Kazuyuki Iwata [b], Shunsuke Managi [c, *]

[a] Graduate School of Fisheries and Environmental Sciences, Nagasaki University, 1-14 Bunkyo-machi, Nagasaki, 852-8521, Japan
[b] Faculty of Economics, Matsuyama University, Japan
[c] Urban Institute & Department of Urban and Environmental Engineering, School of Engineering, Kyushu University, Japan

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ABSTRACT

Urban policy plays an important role in urbanization and urban sprawl, which in turn affect changes in CO_2 emissions from urban areas. However, urban planning policies that consider climate change mitigation have not been widely adopted, despite the issue's importance. To promote the consideration of climate change policies in urban planning, it is useful to identify the key determinants of effective climate change mitigation for policy makers. The objective of this study is therefore to identify the determining factors that affect changes in urban CO_2 emissions based on city type using a dataset of metropolitan areas. We obtained data on 276 cities in 26 countries for the years 2000, 2005, and 2008. We divided the data into five regional groups and four clusters to control for the characteristics of metropolitan areas. The dataset includes urban CO_2 emissions, GDP, and population. Three variables related to urban characteristics are subjected to determinants analysis using an econometric approach. The results show that the determinants of changes in urban CO_2 emissions differ by city type and region. These results contribute to a better understanding of urban policies that can improve the effects of these driving factors by considering the characteristics of each city type.

1. Introduction

Urban policy plays an important role in urbanization and urban sprawl, which in turn affect changes in greenhouse gas (GHG) emissions from urban areas (Hendrickson et al., 2016). According to Fragkias et al. (2013), 60%–80% of global energy use was consumed in urban areas in recent years, and more than 70% of global GHG emissions are produced within urban areas. The OECD (2014) noted that cities can play a key role in addressing global climate change through smart urban design and planning.

Given this situation, urban climate mitigation activities have been promoted by city leaders to protect their cities against the threat of natural disasters (Rosenzweig et al., 2010). The World Mayoors Council on Climate Change (WMCCC) was founded in 2005 to strengthen cities' commitment to climate change mitigation. In January 2017, 88 members of the council developed a network of local government activities that can reduce GHG emissions. In addition, non-party stakeholders[1] including city and local governments are required to scale up their climate mitigation activities with the adoption of the Paris agreement (UNFCCC, 2015).

However, urban policies that consider climate change mitigation have not been widely adopted (Broto and Bulkeley, 2013; OECD, 2014), and the trade-off relationship between climate mitigation and economic competitiveness or social issues is one major reason (Viguié and Hallegatte, 2012). Therefore, the balance between economics, social issues, and the environment is an important factor in developing urban sustainability policies because the economic and social situation critically affects the employment ratio and governmental budget resources, which are key components in urban development.

With the increased attention on urban climate policies, the number of studies that focus on urban planning for climate change mitigation and adoption has grown in recent years (Davoudi et al., 2010; Broto, 2017). McDonald et al. (2011) focus on the effects of climate change on future fresh water availability and urban water resources in developing countries. Wamsler et al. (2013) propose a

* Corresponding author.
E-mail address: managi.s@gmail.com (S. Managi).

[1] According to the UNFCCC (2015), non-party stakeholders include civil society, the private sector, financial institutions, cities and other sub-national authorities, local communities and indigenous peoples.

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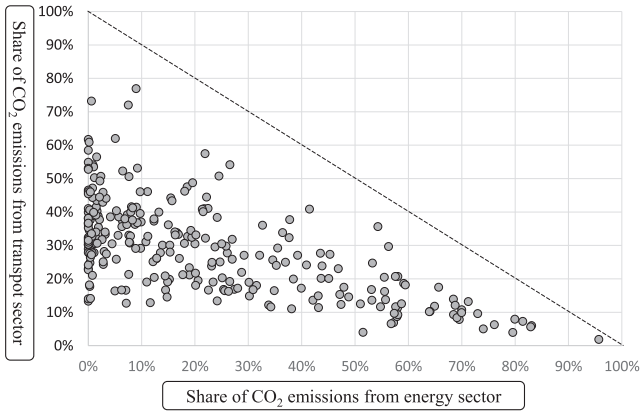

Fig. 1. Scatterplot of CO_2 emissions share in energy and transport sectors in 2008. Source: Figure created by author using metropolitan area data from the OECD.stat database.

conceptual framework for a city disaster nexus that includes urban risk reduction and adaptation strategies for climate change.

Some studies focus on a case study of a specific area. Hendrickson et al. (2016) apply life cycle assessment to evaluate San Francisco's climate change mitigation strategy. Lee and Painter (2015) compare the urban climate change mitigation policies in four cities—Seoul, Busan, Seattle and Anaheim. Damsø et al. (2016) examine the climate action plans of local governments by focusing on the mitigation target level and scope of GHG accounts in Denmark.

There are many studies that analyse urban climate policies and mitigation activities, but few have investigated the key determinants of effective urban climate change mitigation using a large amount of data on metropolitan areas. Additionally, previous studies use cross-country or multiple-city data to identify the key determinants and do not clearly consider the differences in the characteristics of cities and the sources of CO_2 emissions, which can significantly affect the determinants of changes in urban CO_2 emissions.

Lee and Painter (2015) and Mi et al. (2017) note that cities vary in their procedures for planning and implementing GHG mitigation policies. Wiedenhofer et al. (2017) clarify the diversity of the residential carbon footprint among income groups, which strongly affects consumer choice. Additionally, the characteristics of cities are diverse because many conditions differ, including geographies, core industrial sectors, and climate conditions (Fujii and Managi, 2016; Meng et al., 2017). Therefore, cities implement different urban policies because they have different characteristics, and these characteristics must be considered when analysing appropriate urban planning policies and solutions for climate change mitigation.

Major GHG emissions sources differ among cities due to the cities' characteristics and available energy sources (UNEP, 2012). Fig. 1 shows a scatterplot of the share of CO_2 emissions in the energy and transport sector for 276 metropolitan areas in 2008.[2] As shown in Fig. 1, the main sources of CO_2 emissions differ among cities. UNEP (2012) notes that climate change mitigation efforts should be consistent with the desired solutions for major CO_2 emitting sectors in cities. Thus, effective climate change mitigation policies differ among cities that have different sources of CO_2 emissions.

[2] The energy sector includes public electricity, heat production, and other energy industries. The transport sector includes road, rail, and ground transportation.

2. Literature review

There are multiple potential CO_2 emissions sources in cities, such as the transport, industrial, household, commerce and energy sectors, because a city's economic activities are diverse. Therefore, a number of studies from various academic fields have examined the relationship between city characteristics and the CO_2 emissions from corresponding sectors.

When urban forms are changed, including new construction of infrastructure, the most influenced emissions source is the transportation sector because the flows of people and the logistics are changed. Norman et al. (2006) conclude that the most important target for reducing CO_2 emissions is the transport sector. One of the most well-known studies from the first era of such studies is Newman and Kenworthy (1989). Using data from large cities around the world from 1980, they show that per capita gasoline consumption (i.e., CO_2 emissions from vehicles) is higher in low density cities than in high density cities. However, the authors do not consider the other social and economic factors that can influence consumption. Glaeser and Kahn (2010) account for social and economic factors in their analysis and find that CO_2 emissions from vehicles are negatively correlated with population density based on data from 66 large cities in the United States. Using Japanese city data from 1990 to 2010, Iwata and Managi (2016) show the same relationship and conclude that urban policies such as property taxes and land use regulations can be used to increase population densities, thereby reducing CO_2 emissions from vehicles.

With regard to the household sector, Makido et al. (2012) define an index of city complexity and compare 15 Japanese cities using data from 2005. They find that residential per capita CO_2 emissions are lower in less complex cities than in highly complex cities. Analysing 30 provincial capital cities in China, Fang et al. (2015) support the reduction of complexity as a measure for climate change mitigation. Ahmad et al. (2015) analyse approximately 19,000 households' CO_2 emissions data in India, including electricity and cooking, and show that households in high density cities are likely to have lower CO_2 emissions than in low density cities. Norman et al. (2006) divide the Toronto metropolitan area into low and high density areas and compare three types of per capita CO_2 emissions (i.e., transportation, building operations and building materials). The authors conclude that all three types of per capita CO_2 emissions are lower in high density areas than in low density areas. Therefore, urbanization helps to reduce residential CO_2 emissions, not only in developed countries but also in developing counties.

Instead of analysing different sectors' CO_2 emissions, several studies employ a top-down approach, that is, they examine the relationship between the urban form and total CO_2 emissions. Marcotullio et al. (2012) extract data for 3535 urban areas from 45 Asian countries and find that total CO_2 emissions in urban areas are negatively associated with population density. Using a large dataset from 40 countries in Europe that covers 1153 cities with more than 50,000 residents, the same research team, Marcotullio et al. (2014), modify the STIRPAT model to examine the determinants of total CO_2 emissions. The results show that population density is strongly and negatively associated with emissions. Ali et al. (2017) examine the relationship between urbanization (i.e., urban population) and total CO_2 emissions using a long-term dataset from 1970 to 2015 in Singapore, a unique island-city-country. Their main finding is that urbanization is negatively and significantly correlated with emissions. These studies also imply that the promotion of urbanization and increases in population density can mitigate climate change by reducing CO_2 emissions from the household sector.

The literature advocates urban policies such as those described above for combatting climate change. However, some studies