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Keio University

Thesis Abstract

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Thesis Title

Influence of Disruptive Events on Urban Carbon Neutrality Policy: A Multi-Level Comparative Study of Earthquake and Pandemic Cases

Thesis Summary

Cities play a pivotal role in the global transition toward a carbon-neutral society. While numerous carbon reduction plans have been widely introduced, their implementation pathways often follow a linear trajectory, neglecting the uncertainties introduced by disruptive events. Such events can serve as inflection points for transformative change; however, their influence and the underlying mechanisms through which they affect urban carbon trajectories remain underexplored in both research and practice.

This study aims to examine how disruptive events contribute positively to urban carbon mitigation pathways and to assess the institutional potential for supporting low-carbon governance. It does so through an empirical investigation of two significant disruptive events in Tokyo: The Great East Japan Earthquake (2011) and the COVID-19 pandemic (2020). To achieve these objectives, a three-level analytical framework—Disruptive Context, Urban System, and Adaptive Practices—was developed.

Taking the Disruptive Context at macro level as background, an environmental extended input-output (EEIOA) model was constructed to trace cross-sectoral carbon flows and detect structural shifts in the urban system between 2011 and 2015. At the practices level, a life cycle assessment (LCA) approach was employed to evaluate the carbon intensity of shifts in consumer behavior during the COVID-19 pandemic, specifically in the context of online food delivery (OFD) services. By situating both cases within the same three-tiered framework, the study successfully captured the nexus effects of urban sectors under external shocks, identified systemic responses, and assessed the low-carbon potential of practices from both supply- and demand-side perspectives.

The results demonstrate that the earthquake-induced policies led to significant reductions in CO_2 emissions: 20.84% in electricity supply, 20.54% in electricity transmission and transformation, and 8% in automobile emissions. These findings underscore the necessity of integrating responses to disruptive events into long-term decarbonization strategies, shifting from reactive recovery to proactive, emissions-conscious planning across all sectors. In contrast, the pandemic-induced behavioral changes reduced emissions in the OFD sector by at least 16%, highlighting the importance of pre-disruption education and the role of collective action by governments, industries, academia, and the public. Conceptually and methodologically, this research contributes novel insights to the field of urban climate governance.

The dissertation is structured into the following seven chapters:

- Chapter 1 introduces the research focus, emphasizing how disruptive events—typically

regarded as risks—can act as catalysts for carbon mitigation. It identifies the gap between short-term reactive policies and long-term goals, setting the stage for investigating how distinct types of disruptions affect urban emissions and behavior.

- Chapter 2 provides a systematic review of disruptive events from four resilience-related perspectives: (1) mechanisms of disruption, (2) their impacts, (3) the application of the Multi-Level Perspective (MLP) framework to explain transformation opportunities, and (4) methodological approaches for quantifying carbon emissions, including EEIOA, LCA, and community-scale assessments. This chapter establishes the need for an integrated framework that links disruptions to urban carbon pathways.
- Chapter 3 introduces the three-layered framework—Disruptive Context, Urban System, and Adaptive Practices—and explains the application of EIO analysis for the earthquake case and LCA for behavioral shifts during the pandemic.
- Chapter 4 applies EEIOA to Tokyo's emissions from 2011 to 2015, revealing significant energy conversion losses and a post-earthquake shift toward coal-based power. The analysis exposes tight interlinkages among the energy, transport, and construction sectors, offering insights for post-disruption decarbonization.
- Chapter 5 evaluates CO_2 emissions from OFD during the COVID-19 pandemic, revealing that over 70% of emissions originated from food production. The findings suggest that portion control and low-emission delivery methods can significantly reduce carbon impacts.
- Chapter 6 emphasizes disruptive events as strategic entry points for climate governance. While earthquakes mainly affect upstream production sectors, pandemics influence downstream consumption patterns. The chapter advocates for the integration of disruption-informed planning into long-term strategies and promotes pre-disruption education and multi-stakeholder collaboration.
- Chapter 7 concludes by framing disruptive events as opportunities for accelerating low-carbon transitions. Despite differing emission patterns depending on event type, upstream sectors are typically more affected. Effective carbon governance, therefore, demands cross-sectoral cooperation involving governmental bodies, industries, academic institutions, and civil society. The proposed analytical framework and comparative case study approach provide practical tools for future urban carbon mitigation planning.

Overall, this study presents a novel perspective by positioning disruptive events not merely as threats but as potential catalysts for carbon reduction. Unlike previous research that focuses predominantly on planned mitigation efforts or the socio-economic consequences of disruptions, this study emphasizes how reactive disruptions can reshape urban carbon trajectories. Through the analysis of two distinct cases, it demonstrates that different types of disruptions affect emissions through distinct mechanisms: the 3.11 earthquake triggered structural shifts in the energy sector—particularly a rise in coal use and increased construction activities—leading to heightened emissions, whereas the COVID-19 pandemic altered consumer behavior, especially in food-related consumption, with food production accounting for over 70% of emissions in OFD. These findings

suggest that aligning decarbonization strategies with the structural or behavioral nature of the disruption is essential for fostering resilient and low-carbon urban systems. The conceptual framework is applicable to any types of disruptive events, such as extreme weather events, armed conflicts, or financial crises.

Despite its contributions, the study acknowledges several limitations. First, the reclassification of the input-output table—while tailored to Tokyo's context—relied on data from only two years (2011 and 2015), limiting the temporal continuity of the carbon trend analysis. Second, the OFD analysis, although methodologically rigorous, drew on outdated secondary data and did not account for common delivery items such as utensils and napkins, potentially underestimating total emissions. Future research should address these limitations by incorporating continuous and updated datasets, expanding environmental indicators, and broadening system boundaries for more comprehensive evaluations.

Keywords: Disruptive Events, Carbon Neutrality, Multi-Level Perspective, Input-Output Analysis, Life Cycle Assessment