Extended abstract

Spatial Analysis of Photovoltaic Adoption in Urban Settings: A Case Study of Amsterdam (2016-2023)

Erkinai Derkenbaeva[1,2]

[1]Wageningen University and Research, 6706 KN Wageningen, The Netherlands

[2]Amsterdam Institute for Advanced Metropolitan Solutions, 1018 JA Amsterdam, The Netherlands

Abstract

As urban areas face increasing energy demands and the challenges of climate change, the adoption of photovoltaic (PV) systems is crucial for enhancing energy security and promoting sustainable development. This study investigates the spatial distribution and temporal trends of PV adoption in Amsterdam from 2016 to 2023, with a focus on various building types, including residential and commercial structures. Using geographic information system (GIS) data, the research maps PV installation locations and conducts spatial autocorrelation analysis to identify hotspots of adoption. Regression analyses explore the relationship between building characteristics (e.g., age and type) and PV uptake, as well as the influence of household demographics on residential PV adoption. The findings reveal distinct spatial patterns, with high adoption concentrations in specific neighborhoods, often linked to favorable socio-economic and infrastructural conditions. Conversely, other areas exhibit lower adoption rates, indicating barriers related to urban density, building constraints, and lagging uptake in multi-unit dwellings. Additionally, demographic factors, including the prevalence of younger populations, single-person households, and families without children, are identified as critical factors influencing PV adoption. The study's outcomes highlight the need for targeted interventions to overcome adoption barriers and ensure equitable access to sustainable energy solutions. Ultimately, the research aims to provide actionable insights for policymakers and urban planners to design policies that support the widespread adoption of PV systems in Amsterdam, fostering a more sustainable urban energy future.

Keywords

Energy Transition, Solar Photovoltaic Adoption, Urban Areas, Amsterdam, Households

1. Introduction

The rapid expansion of solar energy adoption, particularly through photovoltaic (PV) systems, is central to advancing sustainable energy solutions and reducing urban carbon footprints. In urban settings, where space is limited and energy demand is high, the adoption of PV technology presents unique opportunities and challenges. The distribution of PV installations often varies significantly due to a range of social, economic, regulatory, and physical factors. This study investigates the spatial distribution of photovoltaic installations in Amsterdam, a city known for its progressive sustainability policies. By examining the geographic distribution of installations and the underlying drivers—such as demographic trends, building types, and municipal policies—this research seeks to provide insights into the factors that influence solar energy uptake in (similar) cities. The findings aim to inform more targeted city policies and strategies to enhance the scalability and equity of solar energy deployment in urban areas.

This study aims to explore the role of location in PV adoption in Amsterdam, as well as to identify the factors and barriers influencing it. To achieve this, the study begins by analyzing temporal and spatial trends in PV adoption between 2016 and 2023 using municipal data, followed by a spatial autocorrelation analysis. Next, the study employs regression analysis to examine how building characteristics relate to PV adoption rates within the same dataset. Finally, to gain a comprehensive understanding of the factors and barriers affecting PV adoption, the study investigate the influence of household characteristics by conducting an additional regression analysis with survey data from Amsterdam households collected by the municipality in 2018, 2020, 2022, and 2023.

2. Method and Data

This study employs a multi-method approach to examine PV adoption in Amsterdam, combining systematic and synthetic literature reviews, as well as advanced temporal, spatial, and regression analyses. The systematic literature review first offers a structured and methodical examination of the relevant studies, ensuring a thorough and objective collection of evidence on the factors influencing PV adoption. This includes a review of studies that employ diverse methodologies, geographic contexts, and temporal scales, allowing for the identification of key trends and patterns in the literature. On the other hand, the synthetic literature review goes beyond summarizing individual studies by integrating findings across various research contributions, critically analyzing the broader implications, and drawing connections between different theoretical frameworks, models, and empirical results. By combining these two literature review approaches, the literature review not only seeks to identify the current state of knowledge but also to highlight gaps and contradictions, providing a robust foundation for the current study of PV adoption in Amsterdam.

In addition to the literature reviews, a temporal analysis is conducted to describe the trends in PV adoption over time, exploring how different built environment characteristics influence these trends. The spatial analysis, utilizing spatial autocorrelation, investigates the clustering patterns of PV installations in Amsterdam, applying both global and local autocorrelation models (Global Moran's I and Local Moran's I) to detect spatial dependencies in the distribution of PV systems. Finally, logistic regression models are employed for both buildings and households, identifying the key factors influencing PV adoption across different neighborhoods in Amsterdam from 2016 to 2023. This mixed-method approach provides a comprehensive understanding of the spatial and temporal dynamics of PV adoption, offering valuable insights into the factors that shape the adoption patterns in urban settings.

This investigation utilizes two primary datasets: data on PV installations in Amsterdam from 2016 to 2023 and household survey data. Both datasets are provided by the Municipality of Amsterdam and are not available through open-access channels. Additionally, this study leverages open-access sources to incorporate other relevant variables into the analysis, providing a comprehensive overview of the dynamics driving PV adoption.

3. Tentative results

The spatial distribution of PV installations in Amsterdam reveals clear patterns of success, barriers, and opportunities for intervention through clustered PV adoptions observed. Hotspots and high-high clusters, concentrated in specific neighborhoods, showcase areas of high adoption driven by (presumably) favorable socio-economic/demographic and infrastructural conditions. Conversely, cold spots and low-low clusters, particularly in Centrum, West, and Zuid, highlight significant barriers such as urban density, physical constraints, and lagging adoption in commercial/work and multi-apartment buildings. Outliers, including high-low and low-high clusters, reveal unique localized patterns where successes can be scaled or specific barriers addressed. Furthermore, demographic insights indicate that younger populations under 35, single-person and single-parent households, and families without children require focused support, as do lagging districts such as Zuid and Centrum. Collectively, the distribution of PV installations reflects a clustered pattern influenced by urban structure, socio-economic conditions, and existing policies, underscoring the need for targeted, context-specific interventions to ensure equitable and widespread PV adoption across Amsterdam.

4. Conclusion and Policy Implication

In conclusion, this study provides an analysis of PV adoption patterns in Amsterdam, revealing significant spatial and temporal trends influenced by both building and household characteristics.

The findings highlight the need for targeted, context-specific interventions to overcome barriers and promote equitable access to sustainable energy. The study offers actionable insights for policymakers and urban planners, advocating for tailored strategies that foster widespread and inclusive PV adoption across urban environments.