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An investigation into the impact of green buildings on Swedish municipalities' built environment

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Abstract

- **Objectives**: this paper aims to assess the economic, social and environmental impacts of the green buildings projects that were financed by Swedish municipalities through the green bonds scheme in Sweden.
- **Data**: residential units characteristics as well as geographical information are collected by relying on municipalities' reports. Such characteristics include the environmental impact, as measured in terms of avoided emissions, and the financial impact, as measured in necessary investments. Proximity to basic services is assessed by relying on the OpenStreetMap initiative.
- **Methodology**: environmental impact is assessed by focusing on the emissions reduction potential of each project. Economic impact is assessed by looking at the sources and dimensions of the financial needs of each project. Social impact is estimated by considering the distance of the residential units from basic services and goods providers. Results from the social impact are aggregated using the Shimble Index.
- **Findings**: large heterogeneity is observed across the three assessments. While some municipalities have been able to make an efficient use of the resources, as measured in emissions avoided per unit of currency, others have failed to do so and faced high investments costs to be able to reduce the emissions from their green buildings projects. The accessibility index shows a large variance as well: some of the projects have been able to supply housing units that allow people to access basic services as goods within reasonable distances while others have failed to do so. Accessibility to services and goods must be improved in the latter case to make possible for these projects to increase inclusivity and prevent exclusion and isolation.

Keywords: Green buildings[1], Green bonds [2], Municipalities[3], Sweden[4], Accessibility[5]

1 Introduction

Sweden has matured a long history in providing its citizen with social housing services. This history began to develop around the 1960s and the 1970s with the Million Homes Program, a state-subsided rental housing stock policy (Lind 2014). Since the 1990s, the presence of public housing stock on the Swedish real estate market has significantly reduced due to reasons of lost profitability and privatization strategies ((Hananel, Krefetz, and Vatury 2021)). Yet, the substantial supply of the previous decades determines a situation nowadays where about 300 Municipality Housing Companies

manage 729,000 public housing units and roughly 1.5 million people, about 17% of the Swedish population, live in such units, which account for 20% of the country residential real estate market and 50% of all rentals ((Hananel, Krefetz, and Vatury 2021)).

The abundant resources Swedish municipalities have been able to access to in the recent years thanks to the green bonds financing scheme have provided them with the possibility to influence the appearance and social structure of their urban environments.

While larger municipalities such as Stockholm, Malmö and Gothenburg are large enough to enter the capital market as individual actors, a common approach for small and middle sized municipalities is to join Kommuninvest, a voluntary membership organization which today represents the largest lender to the local government in Sweden (Aleksandrova-Zlatanska and Kalcheva 2019). As of 2022, green buildings represent the largest sector Kommuninvest has provided loans to, with 62% of the disbursed and outstanding green loans portfolio of 63.3 billions SEK (Kommuninvest 2023). Such figures reveal the economic and financial relevance of green buildings projects for small and middle-sized municipalities in Sweden.

The member municipalities and regions of Kommuninvest agree to adhere to impact reporting standards that are shared by other public entities in Norway and Finland as well (Nordic Public Sector Issuers 2020). The presence of common standards allows for a comparison of projects across the Swedish municipalities. The comparison presented here will have short considerations on the financial and environmental sides and will mostly focus on understanding the social impact of the location of the green buildings. Social considerations are intended to be proxied by the number of services or venues people living in these buildings are able to access. In this sense, the analysis fits the previous literature on accessibility (Azmoodeh et al. 2020) and adopt from this the theory that links citizens' quality of life with the possibility to satisfy one's needs, here understood as access to basic services and venues.

2 Data and methodology

The reports by Kommuninvest on the impact of the investments made by the municipalities in green buildings are filtered to account only for buildings with residential purposes. The other buildings in the dataset, mostly schools, kindergartens, and elderly care housing, represent the venues where these services are being offered, and are not necessarily expected to be close to any of the other services. That is, residential units are here intended to be the fulcrum of people's lives and should be located in a position that makes the citizens able to access all the services from these. The other types of green buildings represent the destinations people travel to, rather than from. To sum up, residential units are the ones that are meant to be the subject of the accessibility analysis: is it possible to reach services and places of interest from where they were located by the municipality? Another filter is applied and deals with the necessity to precisely identify the geographic location of the building. This is needed in order to place the building with enough precision in the city and provides the first step into understanding how inclusive its position is. That is, how easy it is to access services from there. Every project comes with a description but some of these are not detailed enough to guarantee the possibility to obtain the geographic coordinates of the buildings. Descriptions such as "*New residential housing units*" do not provide enough details to identify a building beyond any reasonable doubt.

The data for the economic and the environmental assessment are also provided by Kommuninvest. The municipalities that adhere to the green bonds initiative commit to report their investments and their environmental impact, measured in annual tons of CO_2-eq avoided every year, when compared to the standards defined by the national authorities.

2.1 Social assessment

The social assessment built on the data provided by Kommuninvest and the availability of geographical distribution of services and venues through the OpenStreetMap (OSM) initiative (OpenStreetMap 2022). Queries are used to interact with the OSM database through its API service, Overpass Turbo. Our focus here is on the type of service or good that is provided and the geographical coordinates. This allows us to understand what can be accessed within a certain distance. The GeoPy Python package is used to compute the distance of every building from the closest service or venue of interest. A network analysis approach is applied: goods and services within a certain radius (about 20 km) are mapped together with the streets grid. The distance to each of these goods and services along the street grid from the target residential unit is computed. For every type of service or goods, we only keep the one that is the closest, here intended as the one that could be reached in the shortest distance along the street grid. The essential services every citizen should have an easy access to are built on similar studies performed by the previous literature (Witten et al. 2011; Pearce et al. 2006; Kalpana et al. 2019; Haldar et al. 2023) and include: convenience stores, banks, post offices, schools, public transport stops in the form of bus lines and train lines, pharmacies pubs, bars, libraries, cafes and sport venues such as swimming pools and gyms. These venues are meant to represent places where people can access basic services and goods and spaces for public gatherings.

While we did not produce any new figures from the ones that Kommuninvest already made available to perform the economic and the environmental assessments, we only do so for the social assessment. We rely on the Shimbel Index, following in the footsteps of the previous literature ((Daniel et al. 2020; Haldar et al. 2023; Kalpana, et al. 2019; Rajbanshi et al. 2022; Sarkar et al. 2021). The index is constructed in the fashion of Sarkar et al. (2021). We identified, based on the previous literature, a serious of destination points that represent services or relevant venues: distances from bus and train stops, distances from sport facilities, distance from supermarkets and general stores, distances from libraries, distances from cafes and bars and distances from schools. For every building we compute the distance of the closest venue of each of these services and then sum them:

$$\boldsymbol{I_i(j) = \sum_{j=1,N} d_j} \tag{1}$$

Having constructed the index this way we have established a negative relationship between the value of the index and the degree of accessibility to services: the shortest the distance to each of the essential services, the better the location of the building and the better the accessibility. The assumption when using such an approach is that every service and every good is judged to be of the same importance for the citizen. While that is clearly not always true, given the source of our data, it is impossible for us to assess which of these are valued to most. A more profound approach may be adopted by asking citizens to value the services and then by assigning weights to them when computing the final index. Failing to do so represents a clear limitation of this study.

3 Results

3.1 Economic assessment

As of the 2022 report, Kommuninvest has committed to financing about 5.4 billion SEK, of which only 4.8 billion SEK have been disbursed (89%). Umeå kommun is the receiver of the largest amount for the single project, with Kommuninvest committing 656 millions SEK for the "*Production of new low-energy multy-family housing units, including Sustainable Ålidhem area"* , completed in 2017. Not surprisingly, the project Kommuninvest has committed the smallest amount to is a renovation project, i.e. it does not entail the construction of a new building: the "*the extensive renovation of multi-family housing unit (Visvägen) to reduce energy consumption*" by Uddevalla Kommun., completed in 2018. On average, Kommuninvest has provided about 79% of the financial resources the municipalities needed to complete their projects. The rest of capital came from other sources.

3.2 Environmental assessment

The reporting standards to which the municipalities adhere to impose them to classify their investments in one of the following three categories: mitigation (M), adaptation (A) and environmental management (E). All the projects classified as green buildings measures are labeled as mitigation initiatives, with the reasoning that their main goal is to contribute to a reduction in emissions.

Overall, the resources provided by Kommuninvest contribute to a 1,286 Tons of CO_2-eq reduction per year. That is to say, the investments made by the municipalities contributed to a much larger reduction, but the reporting standards require to report the reduced emissions in the same share as the share of financing provided by Kommuninvest. The bulk of the impact in terms of emissions reduction comes from the energy savings green buildings can enable. On that note, the investments made possible through the financing scheme put in place by Kommuninvest allowed to save about 8,615 MWh of energy. A rough measure of how efficient each of these projects was in delivering a reduction in emissions can be computed as the ratio between the saved emissions and the amount disbursed. The result indicates that Nordmaling Kommun managed to reduce 1,04 ton CO_2-eq emissions per million of SEK with its multi-family residential building project in Draken. On the opposite side we find the passive houses project by Kungsbacka municipality, with 0,05 ton CO_2-eq emissions reduced per million SEK invested.

3.3 Social assessment

The results from the social assessment display a lower degree of heterogeneity when compared to those of the economic and environmental assessments. The average computed Shimbel index is around 9 km, as the sum of all the distances to the closest venues/points of interest. This implies that the closest venue/point of interest is at an average distance of 1,2 km. Caution should be employed when assessing the value of these results for two main reasons: 1) many projects involved the construction of multiple buildings and we aimed, where possible, to map all of them, resulting then in a potential over-representation of some projects in the computation; 2) in same cases, extreme values may drive final figure upwards, especially in the cases of libraries, which are often found to be at distances overing around 12 km from the buildings.

Overall, the municipalities have the potential to influence people's quality of life by guaranteeing that the housing services that they provide contribute to a sustainable future, do so in a resource-efficient

way, and guarantee that people will be allowed to meet their essential needs. The analysis proposed here reveals that not all municipalities are able to do so and the scope for improvement is still large.

Conflict of Interest

The authors declare no competing interests.

Author Contributions

All authors contribute to the same extent to this work. All authors read and approved the final manuscript.

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