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Are tenants willing to pay for energy efficiency? Evidence from a small-scale spatial analysis in Germany

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1. Introduction and Research Question

The buildings sector accounts for 36% of final energy use and 39% of CO_2 emissions globally [1], thus making the sector's decarbonisation indispensable to meeting international climate goals and limiting global temperature rise. Germany forms no exception, however the current energy-efficient refurbishment rate (1% p.a.) remains below the country's official political target of 2% p.a. [2].

Both the rate and depth of energy refurbishments differs between owner-occupiers and rental properties, with private landlords and homeowner associations having the comparatively largest refurbishment backlog [3]. One explanation for this is the split incentives present in rental markets, where most of the unlocked co-benefits of energy-efficient retrofits ultimately benefit the tenant and not the landlord. Due to this so-called 'landlord-tenant dilemma' [4-5], energy-efficient retrofitting in rental properties tends to be most attractive to landlords when it also leads to long-term economic benefits.

Numerous studies thus examine and quantify the willingness to pay (WTP) a premium for energy efficiency in the residential sector [6-8]. Findings to-date generally identify larger energy efficiency premiums in the sales than in the rental market [7, 9-10]. However, the presence of such premiums is not ubiquitous [11-12]; additionally, many conventional hedonic modelling approaches do not account for spatial dependence – although its omission can lead to biased and overestimated results [13]. Indeed, spatial analyses have found price premiums to vary significantly across different geographical locations [14] and even within a single city [15].

Given the variability in results, small-scale spatial analyses are needed to provide concrete recommendations for local and national governments and administrations. We aim to address this research gap in the context of the city of Wuppertal, Germany, via examining the impact of the energy performance of a property on rental prices across different residential areas.

2. Data and Method

Data

We used data from the internet platform *Immoscout24.de* (IS24) to illustrate the energy efficiency performance and hedonic characteristics of rental properties. IS24 is Germany's largest real estate platform, with a market share of about 63% [16]. The dataset contains all advertisements for Wuppertal that were published from 2012 to 2019. We combined the georeferenced dataset with building-block-level data on socio-economic statistics and built environment characteristics provided by the City of Wuppertal. In total, our dataset contains 12,232 entries.

Method

Both a hedonic ordinary least squares (OLS) semi-log regression model and a spatial error model (SEM) were applied to the data with the listed price per square meter for apartment rents as the dependent variable. The latter is expressed by the following equation:

$$\ln(\text{price}_i) = \alpha + \beta EE_i + \gamma H_i + \delta N_i + \mu T_i + u_i$$

with

$$u_i = \lambda w_i * u_j + \varepsilon_i$$

where EE represents the energy efficiency performance of the apartment based on the EPC (Energy Performance Certificate; measured in kWh/sqm*a), H represents the apartment characteristics (e.g. fitted kitchen, building age, living space), N represents the neighbourhood characteristics (e.g. population density, unemployment rate) and T represents a series of dummy variables to control for time-fixed effects. ε represents the error term; u_i and u_j are the error terms at locations i and j, respectively, w_i being a vector that expresses the spatial relationship (weights matrix) and λ is the coefficient of spatial component errors.

In a second analysis, we subset the data set based on four residential areas to assess small-scale spatial differences between the tenants' WTP.

3. Results and Findings

We identify spatial autocorrelation in the dependent variable (Moran's I=.493, z-value=121.23, $p<.001$) and spatial dependency in the residuals of the OLS model (Moran's $I_{\text{Residuals}}$=.32, $p<.001$). As also supported by the lower Akaike information criterion (AIC) value and the overall higher fit of the model, we therefore focus on the results of the SEM model.

The model was found to explain a significant amount of the variance in rental prices (LR=3,263.20, p<.001), with a Nagelkerke Pseudo R^2 of 0.61, indicating a reasonable goodness of fit. In line with other studies, the model provides evidence of a price premium for energy efficiency. The effect is statistically significant ($b_{\text{Energy Performance}}$= -0.00017, $p<.001$), but the effect size is small and can be interpreted as follows: the willingness to pay increases by 0.017% for each improvement in energy efficiency of 1 kWh/sqm*a. Comparing the relative influence of other apartment features on rental prices shows that other features lead to larger relative increases in rental prices (e.g. 3.7% for a fitted kitchen).

The second analysis shows that improvements in energy efficiency lead to increasingly higher rental prices in average and good residential areas respectively, but not in simple residential areas, where it is in fact penalised with a discount ($b_{\text{Energy Performance}}$=0.00014, $p<.05$).

4. Discussions and Conclusions

Our results confirm a premium for energy efficiency in the rental market of Wuppertal. However, the premium is small, both compared to other apartment features and in absolute terms, so that investments in energy efficiency are hardly economically viable for landlords. While actual renovation costs depend very much on the building in question, sample calculations based on our dataset suggest long payback periods; no evidence of easier re-letting and reduced vacant periods of a property was further found. The WTP is thus currently not sufficient to refinance the energy-related renovation costs via the market within a reasonable time frame and in light of existing opportunity costs, the incentive for landlords to invest in visible apartment features or in ecological heating systems is higher.

Our analysis thus provides not only an explanation for the backlog in (low-demand) rental housing markets, but also leads to concrete recommendations to overcome this market failure: Firstly, other refinancing models are needed and regulatory instruments such as a refurbishment obligation or mandatory standards for energy efficiency should be considered. The varied results obtained across the four residential areas further demand a spatial differentiation of the funding framework.

Secondly, stronger incentives are needed for tenants to make energy efficiency a relevant rental criterion and to demand it on the market (e.g. via campaigns, a higher CO_2 price, rising energy prices). Given tenants' significantly higher WTP for renewable heating technologies, the relative roles of energy efficiency and renewable energies in achieving climate-neutral building stock may need to shift.

Finally, investments in energy efficiency and the associated cost allocations are in danger of furthering existing social segregation tendencies in rental markets and should, therefore, be considered against the backdrop of social and urban development policy objectives.

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