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A D-Vine Copula Quantile Regression Approach for the Prediction of Residential Heating Energy Consumption Based on Historical Data

by

Rochus Niemierko, Jannick Töppel, Timm Tränkler

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University of Augsburg, D-86135 Augsburg
Visitors: Universitätsstr. 12, 86159 Augsburg
Phone: +49 821 598-4801 (Fax: -4899)

University of Bayreuth, D-95440 Bayreuth
Visitors: Wittelsbacherring 10, 95444 Bayreuth
Phone: +49 921 55-4710 (Fax: -844710)

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Keywords Data-Driven Heating Energy Analysis; Energetic Retrofitting; Quantile Regression; D-Vine Copula; Rebound Effect

Abstract

Energetic retrofitting of residential buildings is poised to play an important role in the achievement of ambitious global climate targets. A prerequisite for purposeful policy-making and private investments is the accurate prediction of energy consumption. Building energy models are mostly based on engineering methods quantifying theoretical energy consumption. However, a performance gap between predicted and actual consumption has been identified in literature. Data-driven methods using historical data can potentially overcome this issue. The D-vine copula-based quantile regression model used in this study achieved very good fitting results based on a representative data set comprising 25,000 German households. The findings suggest that quantile regression increases transparency by analyzing the entire distribution of heating energy consumption for individual building characteristics. More specifically, the analyses reveal the following exemplary insights. First, for different levels of energy efficiency, the rebound effect exhibits cyclical behavior and significantly varies across quantiles. Second, very energy-conscious and energy-wasteful households are prone to more extreme rebound effects. Third, with regards to the performance gap, heating energy demand of inefficient buildings is systematically underestimated, while it is overestimated for efficient buildings.