ALLEVIATING FUEL POVERTY: AN AGENT-BASED MODELING APPROACH TO POLICY EVALUATION

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Overview

Inadequate access to affordable, safe, and reliable energy services deprives individuals of the essential means to lead a decent and equitable life.This problem is particularly pressing in low-income neighborhoods, where inability to meet energy costs is a reflection of larger distributional inequalities and socioeconomic disparities [1]. Addressing fuel poverty requires a comprehensive approach that includes understanding the behavioral economics principles influencing household energy consumption decisions and offering policy interventions like subsidies. Scarcity strains cognitive resources, often causing households to overlook participation in energy efficiency programs that offer long-term benefits in favor of meeting immediate needs [4]. This study applies an agent-based modeling (ABM) approach to evaluate the impact of policy interventions designed to alleviate fuel poverty. The model simulates household-level attributes from the English Housing Survey (EHS), including income, fuel expenditures, dwelling characteristics, and eligibility for energy support schemes (e.g., ECO Affordable Warmth and Warm Home Discount) [2]. The integration of behavioral economic principles, including present bias, loss aversion, and social norm, reflects the cognitive and economic barriers that households face in decision-making situations where resources are scarce [3].

Methods

This study employs an agent-based modeling (ABM) approach to evaluate the impact of different policy interventions aimed at alleviating fuel poverty. The simulation includes four distinct scenarios, each representing a specific type of intervention. First, the baseline scenario assumes no policy intervention, capturing the natural progression of fuel poverty without external support. The subsidy scenario focuses on improving affordability by reducing fuel costs for eligible households, providing immediate financial relief to address energy expenses. The grant scenario offers direct financial support to facilitate energy-saving investments, such as upgrading heating systems and improving insulation. The nudge scenario encourages households to adopt energy-saving practices through behavioral interventions, addressing barriers such as decision-making inertia and cognitive biases that often prevent energy-saving actions. The simulation was conducted over 30 time steps, representing approximately 30 years of policy implementation and household adaptation. Within this framework, the ABM approach monitors changes in fuel poverty status by evaluating eligibility criteria, behavioral responses, and social influences. The model incorporates behavioral economic principles to capture the cognitive and financial barriers households face when making energy-related decisions. Present bias reflects households' tendency to prioritize immediate financial relief over long-term benefits, often delaying investments in energy-efficient upgrades. Loss aversion accounts for households' sensitivity to the upfront costs of such upgrades, which are perceived as risks despite their long-term savings potential. Social norms, models through peer influence thresholds, highlight how households' decisions are influenced by the behaviors of others within their peer groups. To assess the robustness of the model, sensitivity analysis is conducted by varying key behavioral parameters, such as thresholds for present bias, loss aversion, and peer influence.

Results

The findings highlight that the varying effectiveness of policy interventions in alleviating fuel poverty. The grant scenario proves to be the most impactful, achieving a 61.5% reduction in fuel-poor households by enabling substantial energy-efficiency investments, such as the adoption of energy-efficient appliances like boilers. Subsidies, while less impactful in the long term, reduce fuel poverty by 34.3% by addressing immediate affordability gaps and offering short-term relief for housholds struggling with energy costs. Nudges, which were found to result in a 50.2% reduction in the number of fuel-poor households, effectively address behavioral barriers and encourage efficiency improvements.

Conclusions

The study demonstrates the importance of using survey-based insights and long-term simulations to evaluate policy interventions. The findings suggest that a multifaceted approach combining financial support, behavioral nudges, and structural improvements is essential for reducing fuel poverty and enhancing energy resilience. Incorporating household characteristics such as type of heating system, income levels, and peer influence (social norm) into policy design can improve outcomes and ensure equitable energy affordability.

References

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