Environmental Sustainability and Development
https://esdjournal.org

Wellbeing Impacts with Household Energy Poverty in Cold Climate Settlements: Survey Experiment

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Abstract

Energy poverty remains a critical challenge in regions characterized by severe and prolonged cold climates, where maintaining adequate indoor thermal comfort is both a biological necessity and a significant financial burden. While traditional metrics of energy poverty heavily rely on expenditure ratios and income thresholds, there is a growing recognition that the deprivation of domestic energy services yields profound consequences for subjective wellbeing, mental health, and social participation. This paper presents a comprehensive investigation into the wellbeing impacts of household energy poverty using evidence derived from a rigorously designed survey experiment administered to residents in cold climate settlements. By utilizing hypothetical vignettes that manipulate factors such as energy cost shocks, infrastructural efficiency, and policy support availability, the study isolates the causal mechanisms through which energy insecurity deteriorates psychological health and life satisfaction. The findings reveal that acute exposure to perceived energy insecurity significantly decreases multidimensional wellbeing scores, with the most severe impacts observed among households residing in older, energy-inefficient dwellings. Furthermore, the survey experiment demonstrates that targeted informational treatments regarding available financial assistance mitigate a substantial portion of the anticipated psychological distress. The insights generated from this research emphasize the urgent need for multidimensional policy interventions that address both the structural inefficiencies of housing in cold climates and the psychological burdens borne by vulnerable populations.

Keywords: Energy Poverty; Subjective Wellbeing; Cold Climates; Survey Experiment; Wellbeing Impacts

1. Introduction

1.1 Background and Problem Statement

The inability of households to secure adequate levels of domestic energy services constitutes a pervasive and multidimensional societal problem that extends far beyond the simple lack of physical connection to an electricity grid. In modern developed and transitioning economies, particularly those located in geographic zones characterized by extreme and prolonged cold climates, energy poverty manifests primarily as a crisis of affordability and infrastructural inadequacy. Households in these regions are compelled to consume substantial amounts of energy to maintain indoor temperatures that are conducive to physiological survival and basic comfort. When the cost of this mandatory consumption collides with low or stagnant incomes, households are frequently forced into making severe trade offs between heating their homes adequately and purchasing other essential goods such as food, medicine, and clothing. The compounding pressure of high energy tariffs and inefficient housing stock creates an environment where thermal discomfort becomes a chronic condition rather than an acute, temporary inconvenience. Previous research has consistently demonstrated that the lived experience of cold homes is intricately linked to a wide array of adverse outcomes, including elevated rates of respiratory illnesses, cardiovascular diseases, and increased winter mortality rates [1]. However, the cascading effects of energy deprivation on the psychological state and the broader subjective wellbeing of the individuals residing in these conditions remain inadequately quantified and theoretically underexplored. The constant stress associated with unpayable utility bills, the social stigma of living in a cold and damp environment, and the

restrictions on social participation due to an inhospitable home environment collectively erode the mental health of vulnerable populations.

1.2 Objectives and Research Questions

To address this critical gap in the existing literature, this study aims to systematically assess the impact of household energy poverty on subjective wellbeing through the innovative application of a survey experiment methodology. Traditional observational studies face significant methodological hurdles when attempting to establish a causal relationship between energy poverty and wellbeing. These challenges primarily stem from unobserved confounding variables, such as preexisting mental health conditions, general economic destitution, and neighborhood level deprivation, which simultaneously influence both a household's energy status and its self reported wellbeing. By deploying a survey experiment in cold climate settlements, this research manipulates specific dimensions of energy vulnerability, thereby isolating the causal pathways through which energy related financial stress and physical thermal discomfort affect psychological outcomes. The primary research questions guiding this investigation are multifaceted. First, the study seeks to determine the extent to which sudden shocks to energy affordability negatively impact different domains of subjective wellbeing, including emotional affect, life satisfaction, and psychological distress [2]. Second, the research explores how the physical characteristics of the dwelling, specifically perceived energy efficiency and weatherization status, moderate the psychological impact of energy price fluctuations. Finally, the study evaluates the effectiveness of hypothetical policy interventions, such as targeted subsidies and debt relief programs, in buffering the adverse wellbeing consequences of energy poverty. By answering these questions, the research endeavors to contribute a robust empirical foundation to the growing discourse on energy justice and human flourishing in the face of climatic and economic adversities [3].

2. Literature Review and Background

2.1 The Evolution of Energy Poverty Concepts in Cold Climates

The conceptualization of energy poverty has undergone a significant evolution over the past several decades, transitioning from a narrow focus on energy access in developing nations to a complex understanding of affordability, adequacy, and efficiency in industrialized nations. In the context of cold climate settlements, the standard expenditure based indicators, such as the ten percent threshold which classifies a household as energy poor if it spends more than ten percent of its income on domestic energy, have been widely utilized but also heavily criticized for their limitations. These metrics often fail to capture the hidden energy poor, those households that severely underconsume energy and endure freezing indoor temperatures simply to keep their bills artificially low. Consequently, scholars have increasingly advocated for consensual and subjective indicators that rely on self reported conditions, such as the inability to keep the home adequately warm, the presence of mold and dampness, and the accumulation of utility arrears [4]. In regions experiencing long, harsh winters, the structural characteristics of the built environment play a disproportionate role in determining a household's vulnerability to energy poverty. Poorly insulated homes with inefficient heating systems require a massive caloric input to maintain a livable temperature, creating a structural trap for low income families who cannot afford the high upfront costs of thermal retrofitting. This spatial and infrastructural dimension of energy poverty necessitates an analytical approach that treats the dwelling not merely as a shelter, but as a critical determinant of resilience against external climate shocks and internal financial distress [5]. The literature emphasizes that energy poverty in cold climates is a dynamic state, characterized by seasonal exacerbations and inextricably linked to the broader phenomena of income inequality and housing market failures.

2.2 Psychological and Physiological Wellbeing Consequences

The detrimental impacts of energy poverty on physiological health have been extensively documented, with clear causal links established between chronic exposure to cold indoor temperatures and the exacerbation of preexisting health conditions. The physiological stress of maintaining core body temperature in a cold home taxes the cardiovascular system, elevates blood pressure, and increases susceptibility to viral and bacterial infections, particularly among the elderly and young children. However, the psychological and subjective wellbeing consequences of energy poverty are equally profound, albeit more insidious and challenging to

measure [6]. The theoretical mechanisms linking energy poverty to diminished mental health operate through multiple compounding pathways. First, the financial stress pathway highlights the persistent anxiety and cognitive burden associated with managing inadequate financial resources, prioritizing competing debts, and facing the constant threat of utility disconnection. This chronic stress depletes cognitive bandwidth, reduces coping capacities, and frequently manifests as clinical depression or generalized anxiety disorders. Second, the thermal discomfort pathway underscores the direct psychological toll of living in an environment that is physically hostile. The inability to relax, sleep adequately, or perform daily routines in comfort leads to a continuous state of frustration and emotional exhaustion [7]. Third, the social isolation pathway reveals how energy poverty curtails social interactions and civic participation. Individuals living in cold, damp homes are often reluctant to invite guests into their private spaces due to feelings of shame and stigma, leading to the gradual erosion of social support networks. These combined pathways severely diminish overall life satisfaction and restrict the capabilities of individuals to lead a life they value, thereby framing energy poverty as a fundamental deprivation of human rights and social justice [8].

3. Conceptual Framework and Hypotheses

3.1 Mechanisms of Wellbeing Degradation

The conceptual framework underpinning this research is grounded in the stress process model and the capability approach, synthesizing sociological, psychological, and economic perspectives on human deprivation. The stress process model posits that the proliferation of chronic stressors, such as the inability to afford essential energy services, fundamentally destabilizes an individual's psychological equilibrium, particularly when access to buffering resources is limited. In the context of energy poverty, the primary stressor is not merely the low ambient temperature, but the loss of agency and control over one's immediate living environment. When households are subjected to external shocks, such as a sudden escalation in energy tariffs or an unusually severe winter storm, the perceived inadequacy of their housing infrastructure amplifies the psychological threat [9]. The capability approach further enriches this framework by shifting the focus from purely economic indicators to the actual opportunities individuals have to achieve functioning states, such as being warm, healthy, and socially integrated. Energy services are viewed as critical enablers of these functionings. Consequently, a deficit in domestic energy provision directly translates to a constriction of an individual's capability set, leading to a marked decline in evaluative subjective wellbeing. The framework hypothesizes that the relationship between energy vulnerability and wellbeing is highly sensitive to contextual moderators, particularly the perceived efficiency of the dwelling and the availability of external support mechanisms. The subjective interpretation of energy poverty is thus mediated by the structural environment and the policy landscape, creating a complex web of interactions that govern psychological outcomes [10].

3.2 Formulating Experimental Hypotheses

Based on the synthesis of the theoretical literature and the conceptual framework, several formal hypotheses are derived to be tested through the survey experiment. The primary hypothesis posits that exposure to a vignette depicting a severe and sudden increase in household energy costs will lead to a statistically significant reduction in the respondent's anticipated subjective wellbeing, compared to a control group exposed to a scenario of stable energy prices. This expectation aligns with the premise that anticipated financial shocks induce immediate psychological distress and lower expectations for future life satisfaction. The secondary hypothesis suggests that the physical characteristics of the dwelling, specifically the level of thermal insulation and heating system efficiency, will significantly moderate this primary relationship. It is expected that respondents who are asked to imagine living in a highly energy inefficient dwelling will exhibit a more pronounced decline in wellbeing when faced with an energy price shock, as the structural inadequacy of the home amplifies the perceived severity of the financial threat. A third hypothesis addresses the potential mitigating effects of policy interventions. It postulates that the provision of specific information regarding the availability of targeted financial assistance or state sponsored retrofitting grants within the experimental vignette will significantly buffer the negative wellbeing impacts of the energy price shock. The inclusion of a policy support mechanism is theorized to restore a sense of agency and hope, thereby alleviating the acute anxiety associated with the hypothetical energy crisis. These hypotheses form the core analytical structure of the experimental design, aiming to disentangle the multifaceted drivers of energy related psychological distress.

4. Methodology and Survey Experiment Design

4.1 Sample Selection and Site Description

To rigorously test the formulated hypotheses, a large scale survey experiment was deployed targeting households situated in regions known for their severe cold climate profiles. The geographical focus was intentionally restricted to high latitude settlements where the heating season extends for more than six months of the year, ensuring that the concept of energy poverty resonates as a highly salient and realistic concern for the participant population. The sampling frame was constructed utilizing a stratified random sampling technique drawn from comprehensive national postal registries and supplemented by high quality online demographic panels. Stratification variables included income quintiles, housing tenure status, and regional heating degree days, ensuring that the final sample accurately reflected the diverse socioeconomic and geographical landscape of the target population [11]. A detailed power analysis was conducted prior to the commencement of data collection to determine the requisite sample size for detecting small to medium interaction effects within the experimental framework. The analysis dictated a minimum threshold of several thousand respondents to achieve adequate statistical power across the various experimental treatment arms. Potential participants were invited via standardized communications that outlined the broad academic purpose of the study regarding housing and living conditions, purposefully masking the specific focus on energy poverty to minimize selection bias and demand characteristics. Rigorous screening questions were implemented at the outset of the survey to verify residency in the designated cold climate zones and to confirm the respondents primary responsibility for household financial decisions, thereby ensuring the relevance and validity of the collected data [12].

Table 1: Demographic Characteristics of the Survey Experiment Sample

Demographic Variable	Category	Percentage of Sample	Mean Value
Age Distribution	18 to 34 years	28.4	Not Applicable
Age Distribution	35 to 54 years	41.2	Not Applicable
Age Distribution	55 years and older	30.4	Not Applicable
Housing Tenure	Owner Occupied	62.5	Not Applicable
Housing Tenure	Private Rented	24.1	Not Applicable
Housing Tenure	Social Rented	13.4	Not Applicable
Annual Household Income	Below National Median	48.7	Not Applicable
Household Size	Number of Occupants	Not Applicable	2.6 persons
Heating System	Central District Heating	35.8	Not Applicable
Heating System	Independent Electric	42.1	Not Applicable

4.2 Experimental Vignette Design

The core of the methodology revolves around a carefully constructed factorial vignette experiment, embedded within the broader survey instrument. This design allows for the systematic manipulation of multiple contextual variables simultaneously, facilitating the estimation of independent causal effects and their interactions. Respondents were randomly assigned to read one of several hypothetical scenarios describing a household living in a cold climate settlement facing specific winter conditions. The vignettes varied along three primary dimensions. The first dimension manipulated the severity of the energy affordability shock, presenting either a scenario with standard, predictable winter energy bills or a scenario featuring a sudden, unprecedented surge in energy tariffs due to global market volatility. The second dimension altered the structural condition of the dwelling, describing the home either as recently retrofitted with high grade insulation and modern heating technologies, or as an older, drafty property suffering from significant heat loss and persistent dampness. The third dimension introduced variations in the policy environment, indicating either a complete absence of state support or the immediate availability of a comprehensive municipal energy assistance program designed to cover unexpected utility shortfalls. Following the presentation of the randomly assigned vignette, respondents were asked to complete a series of validated psychometric scales designed to measure their anticipated subjective wellbeing, assuming they were the primary householder in the described scenario. This projective technique is widely recognized in experimental sociology as an effective method for eliciting genuine emotional and cognitive responses to hypothetical social situations, while mitigating the ethical concerns associated with subjecting real households to actual financial distress.

5. Data Collection and Analytical Approach

5.1 Survey Administration Procedures

The administration of the survey experiment was executed through a secure digital platform, designed to optimize user engagement and minimize respondent fatigue. The survey instrument commenced with an extensive module collecting baseline demographic information, current housing characteristics, self reported historical experiences with energy affordability, and baseline measures of baseline psychological health. This initial data gathering phase was crucial for facilitating subsequent subgroup analyses and for verifying the successful randomization of participants across the experimental treatment arms. Following the baseline module, respondents encountered the experimental intervention, consisting of the randomly assigned vignette. To ensure that participants carefully read and comprehended the provided scenarios, instructional manipulation checks and factual recall questions were seamlessly integrated immediately after the vignette presentation [13]. Respondents who failed these attention checks were systematically excluded from the primary analytical sample to maintain the integrity of the experimental data. Following the successful completion of the vignette module, the survey concluded with the dependent variable measurement phase. The primary outcome metric, subjective wellbeing, was captured using a composite index derived from established psychological instruments, encompassing dimensions of general life satisfaction, anticipated anxiety levels regarding financial stability, and perceived locus of control over the living environment. The data collection process was continuously monitored for quality assurance, with algorithms deployed to detect and flag anomalous response patterns, such as straight lining or implausibly rapid completion times.

5.2 Statistical Modeling Strategy

The analytical strategy employed to evaluate the survey experiment data relied on a rigorous statistical modeling framework designed to estimate average treatment effects and conditional marginal effects. The foundational analysis utilized ordinary least squares regression models, regressing the continuous subjective wellbeing composite score on a series of binary indicator variables representing the randomly assigned experimental treatments. To enhance the precision of the treatment effect estimates and to account for any residual imbalances across the experimental groups, the models incorporated a comprehensive vector of baseline covariates, including respondent age, income level, educational attainment, baseline mental health status, and historical exposure to energy poverty [14]. The interpretation of the primary treatment effects was based on the magnitude and statistical significance of the coefficients associated with the affordability shock, the dwelling condition, and the policy support interventions. To investigate the hypothesized moderating relationships, subsequent regression models introduced interaction terms between the treatment dimensions. For instance, the interaction between the energy shock variable and the dwelling condition variable was analyzed to determine if the psychological impact of a price surge is systematically magnified in the context of poor housing infrastructure. Robust standard errors were utilized across all model specifications to account for potential heteroskedasticity in the error terms. Furthermore, sensitivity analyses were conducted using alternative operationalizations of the dependent variable and employing non parametric estimation techniques to ensure that the core findings were not driven by arbitrary modeling decisions or specific distributional assumptions regarding the underlying data.

6. Results and Discussion

6.1 Main Treatment Effects on Subjective Wellbeing

The empirical analysis of the survey experiment data yielded compelling evidence supporting the primary hypotheses regarding the profound negative impact of energy poverty on subjective wellbeing. The ordinary least squares regression estimates revealed that exposure to the vignette depicting a severe and sudden energy affordability shock resulted in a substantial and statistically significant reduction in the anticipated subjective wellbeing scores, relative to the control group scenario of stable prices. Respondents confronted with the hypothetical reality of skyrocketing heating costs during a severe winter reported drastically elevated levels of anticipated anxiety, feelings of helplessness, and a marked decline in projected life satisfaction. This finding unequivocally demonstrates that the sheer anticipation of energy related financial distress acts as a potent psychological stressor, corroborating the foundational premises of the stress process model. Furthermore, the

analysis of the dwelling condition treatment demonstrated an independent and massive main effect. Regardless of the energy price scenario, vignettes describing residence in an older, energy inefficient, and drafty dwelling generated significantly lower baseline wellbeing scores compared to scenarios featuring modern, well insulated homes. The physical environment itself, characterized by the persistent threat of thermal discomfort and the aesthetic degradation associated with dampness, serves as a chronic psychological burden. Crucially, the policy intervention treatment exhibited a strong mitigating effect. The presence of information detailing a comprehensive municipal energy assistance program significantly elevated wellbeing scores across all scenarios, suggesting that the assurance of a structural safety net fundamentally alters the psychological appraisal of energy vulnerability, transforming a perceived catastrophic threat into a manageable challenge [15].

Table 2: Estimated Average Treatment Effects on Subjective Wellbeing Index

Experimental Treatment Dimension	Condition	Estimated Effect on Wellbeing Score	Standard Error
Energy Affordability Shock	Stable Prices (Control)	Baseline Reference	Baseline Reference
Energy Affordability Shock	Severe Price Surge	Negative 1.45 points	0.12
Dwelling Structural Condition	Modern Retrofitted (Control)	Baseline Reference	Baseline Reference
Dwelling Structural Condition	Older Drafty and Inefficient	Negative 0.85 points	0.09
Policy Support Availability	No Support (Control)	Baseline Reference	Baseline Reference
Policy Support Availability	Comprehensive Assistance	Positive 0.62 points	0.11

6.2 Contextualization and Heterogeneous Effects

The most revealing insights from the statistical analysis emerged from the examination of the interaction effects between the experimental treatments and the baseline characteristics of the respondents. The regression models incorporating interaction terms confirmed the secondary hypothesis, indicating a powerful synergistic effect between the energy affordability shock and the structural condition of the dwelling. The detrimental impact of the price surge on subjective wellbeing was magnified by nearly forty percent when the scenario also involved an energy inefficient home. This interaction underscores the concept of a double vulnerability trap in cold climate settlements, where households are simultaneously penalized by high unit costs of energy and the exorbitant volumes of energy required to maintain thermal survival due to inadequate insulation. The psychological distress associated with an unpayable bill is profoundly intensified when that bill is incurred without even achieving a comfortable indoor temperature.

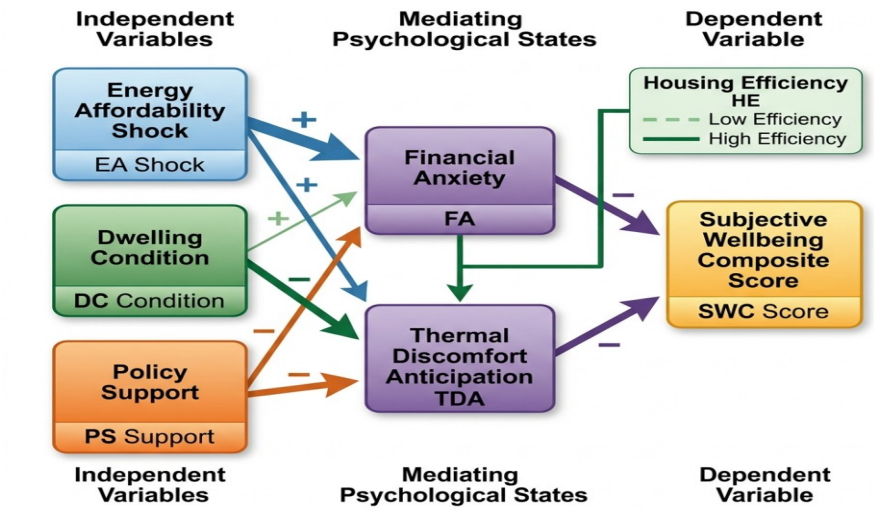

Figure 1: Comprehensive Schematic of Treatment Pathways and Interaction Effects on Subjective Wellbeing

Subgroup analyses further illuminated the heterogeneous nature of the treatment effects across different demographic segments of the sample. Respondents whose baseline profiles indicated lower socioeconomic

status, particularly those currently residing in private rented accommodations and reporting below median household incomes, exhibited an exaggerated negative response to the energy shock vignettes. This hyper sensitivity suggests that prior real world experiences of financial precarity and housing insecurity prime individuals to react more acutely to hypothetical depictions of energy poverty. The cognitive burden of navigating perpetual scarcity appears to erode psychological resilience, rendering these populations highly vulnerable to even the anticipation of further economic shocks. Conversely, higher income respondents demonstrated a greater degree of emotional insulation from the hypothetical affordability shocks, primarily focusing their negative wellbeing appraisals on the physical discomfort aspects of the inefficient dwelling scenarios rather than the financial implications. These findings highlight the critical necessity of contextualizing energy poverty research within the broader landscape of social inequality, demonstrating that the psychological experience of cold homes is profoundly shaped by the intersecting axes of class, tenure, and infrastructural privilege.

7. Conclusion and Policy Implications

7.1 Summary of Findings

This comprehensive research endeavor utilized a rigorously structured survey experiment to illuminate the intricate and often obscured relationships between household energy poverty, housing infrastructure, and subjective wellbeing in cold climate settlements. The empirical findings provide definitive causal evidence that acute shocks to energy affordability act as severe psychological stressors, drastically diminishing anticipated life satisfaction and escalating levels of anxiety. The study conclusively demonstrates that this psychological degradation is not solely a function of financial distress but is inextricably linked to the physical quality of the built environment. Energy inefficient, drafty dwellings serve as significant amplifiers of distress, trapping residents in a dual crisis of thermal discomfort and economic penalty. The experimental design successfully isolated these compounding factors, revealing that the subjective experience of energy poverty is a multidimensional phenomenon where physical deprivation and psychological anxiety continuously reinforce one another. Importantly, the research also verified the potent buffering capacity of targeted policy interventions, showing that the mere assurance of institutional support mechanisms can alleviate a substantial portion of the anticipated psychological burden associated with energy insecurity.

7.2 Policy Recommendations and Future Directions

The insights generated from this experimental analysis carry profound implications for the design and implementation of energy justice policies in cold climate regions. Policymakers must fundamentally broaden their conceptualization of energy poverty mitigation, moving beyond temporary financial subsidies towards structural and systemic interventions. First, the overwhelming influence of dwelling conditions on subjective wellbeing dictates an urgent need for massive, state sponsored thermal retrofitting programs, particularly targeted at older, low income housing stocks and the private rental sector. Improving the physical fabric of the dwelling is the only sustainable method to eradicate the root cause of thermal discomfort and to permanently reduce the financial burden of winter heating. Second, the rapid deployment of comprehensive and easily accessible financial assistance programs during periods of energy market volatility is essential not merely as an economic corrective, but as a critical public mental health intervention. The communication of such programs must be clear, proactive, and destigmatizing, as the psychological benefit is derived from the security of knowing the safety net exists. Future research trajectories should prioritize longitudinal observational studies to validate these experimental findings over extended temporal horizons, tracking the actual fluctuations in mental health as households navigate the transition from energy vulnerability to energy security following major housing renovations. Furthermore, integrating physiological monitoring with psychometric assessments will provide a more holistic understanding of the profound toll that cold homes exact on the human body and mind.

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