Who Accepts and Who Protests Urban SMR Siting? A Risk–Benefit Perspective

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1. Introduction

Small Modular Reactors (SMRs) are often introduced by technology developers as next-generation nuclear systems featuring enhanced safety characteristics [1]. It was also proposed that improved safety performance may allow the reduction of emergency planning zones, potentially relaxing the traditional regulatory requirement that nuclear facilities be located in low-population areas. In parallel, policy developers have shown growing interest in SMRs as distributed energy sources capable of reducing transmission losses and supporting energy-intensive strategic industries such as data centres [2,3]. These technological and economic expectations have expanded the discussion of SMR deployment from remote sites to urban environments. However, while the technical and economic feasibility of urban SMRs has attracted increasing attention, the social dimensions of urban siting remain underexplored. In particular, limited research has examined how urban residents respond when SMR deployment is considered within densely populated settings.

Previous empirical studies have examined economic acceptance using willingness-to-accept (WTA) frameworks and explored the effects of information framing on support levels, and categorized respondents based on their responses in three-tiers [4,5]. These studies clarified how compensation levels and informational contexts influence both stated acceptance rates and WTA amount. However, less attention has been given to the underlying perceptual structure that differentiates those who accept urban SMR siting from those who actively protest. In particular, it remains unclear whether acceptance and protest are primarily structured by a conventional risk–benefit trade-off or by socio-demographic segmentation.

This study addresses this gap by examining the perceptual and socio-demographic profiles of bid acceptors and protestors within the control group of a large-scale (N=2,456) urban survey. Rather than focusing on economic thresholds or protest motivations, this research investigates whether perceived benefit and perceived risk systematically explain acceptance and protest behaviour.

2. Data and Method

2.1. Survey Sample

In a previous study [5], respondents were categorized into three-tiers based on their responses to a double-bounded dichotomous choice question measuring WTA compensation for urban SMR siting [6,7]. Participants were first asked whether they would accept an offered compensation amount. If they rejected both the initial and follow-up bid amounts, they were asked an additional question to distinguish whether the rejection was due to insufficient compensation or due to fundamental opposition to nuclear facility siting in their residential area. Based on these responses, respondents were classified into three-tiers:

- Bid Acceptors
- Conditional Acceptors (rejected bids due to insufficient compensation)
- Protestors (rejected siting regardless of compensation due to underlying aversion)

This distinction allows the separation of economic evaluation from normative or value judgement-based opposition.

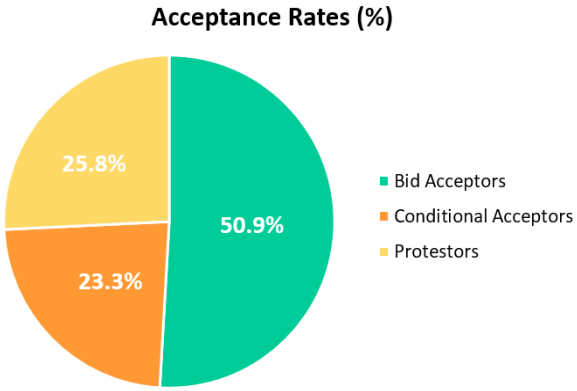

Fig.1. Acceptance Rates of Each Response Tier [4,5]

To identify the baseline perceptual structure without framing influence, this study focuses on control group where no additional information on SMR is given (n=493). As shown in Figure 1, 50.9% of respondents accepted the offered bid, while 25.8% rejected siting regardless of compensation. The relatively large share of protestors highlights the need to distinguish economic evaluation from principled opposition. Accordingly, this study focuses on the contrast between acceptors and protestors.

2.2. Variables

Public acceptance of nuclear technologies has traditionally been understood through a risk–benefit evaluation framework [8,9]. Early work in risk perception research suggests that individuals evaluate technological systems by weighing perceived benefits against perceived risks rather than relying solely on objective technical assessments. In particular, Slovic [9] argues that perceived risk and perceived benefit often exhibit an inverse relationship in public judgment, forming a structured evaluative trade-off that shapes support or opposition toward controversial technologies.

Building on this framework, two key perceptual variables were included in the analysis: perceived benefit and perceived risk. Both constructs were measured using 3 items on a 7-point Likert scale and aggregated into mean scores. Perceived benefit captures evaluations of individual, local, national economic advantages associated with urban SMR deployment, whereas perceived risk reflects concerns regarding catastrophic potential and fatal consequences, technology newness, and controllability of accident.

Two binary dependent variables were constructed based on the responses and 3-Tier classification: bid acceptance (1 = accept, 0 = otherwise) and protest (1 = protest, 0 = otherwise). By estimating separate models for acceptance and protest, the analysis examines whether the conventional risk–benefit trade-off structure explains both supportive and oppositional responses. To isolate the independent effect of perceptual evaluations, socio-demographic characteristics were included as control variables. These variables comprise gender, age, education, income, parental status, house ownership, and occupation [10].

3. Results

3.1. Socio-demographic Distribution

Table 1 presents the socio-demographic composition of bid acceptors and protestors within the control group.

Regarding gender differences, males account for 61.8% of acceptors but only 30.7% of protestors, whereas females represent 69.3% of protestors. Age differences are relatively moderate, although respondents aged 40–49 show a higher share among protestors (33.9%). Education and income levels display limited variation between groups, though protestors show a slightly higher proportion of graduate degree holders and high-income respondents. Parental status and house ownership exhibit some variation, but no single demographic category overwhelmingly defines either acceptance or protest. Overall, the descriptive patterns suggest that demographic segmentation alone does not fully explain divergence between acceptance and protest.

Table I: Socio-demographic Profiles of Tiers

Variable	Category	Bid Accept (%)	Protest (%)
Gender	Male	61.8	30.7
	Female	38.2	69.3
Age	20–29	26.7	23.6
	30–39	24.3	17.3
	40–49	23.5	33.9
	50+	25.5	25.2
Education	High school	20.7	15.7
	Univ.	62.5	62.2
	Graduate	16.7	22.0
Income	Low	33.9	27.6
	Median	40.6	37.8
	High	25.5	34.6
Parental status	With child	23.9	31.5
	Without child	76.1	68.5
House ownership	Own	61.8	70.9
	Others	38.2	29.1
Occupation	Energy-intensive	22.3	11.8
	Others	77.7	88.2

3.2. Risk-Benefit Trade-off Structure

Table II: Multi-variate Regression Analysis Results

Variable	Accept OR (95% CI)	Protest OR (95% CI)
Perceived Benefit	1.80 (1.46–2.23)	0.45 (0.35–0.57)
Perceived Risk	0.56 (0.44–0.69)	1.80 (1.38–2.38)
Female	0.52 (0.34–0.79)	2.41 (1.45–4.08)
High school	0.52 (0.29–0.92)	–
Graduate degree	–	2.66 (1.14–6.34)
Energy-intensive industry	0.54 (0.31–0.94)	–

Note. Only statistically significant results are reported ($p < 0.05$)

Table 2 and Figure 2 present the multivariate logistic regression results for acceptance and protest within the control group. Consistent with the traditional risk–benefit framework, perceived benefit significantly increases the likelihood of acceptance (OR = 1.80, 95% CI: 1.46–2.23), while perceived risk significantly decreases it (OR = 0.56, 95% CI: 0.44–0.69).

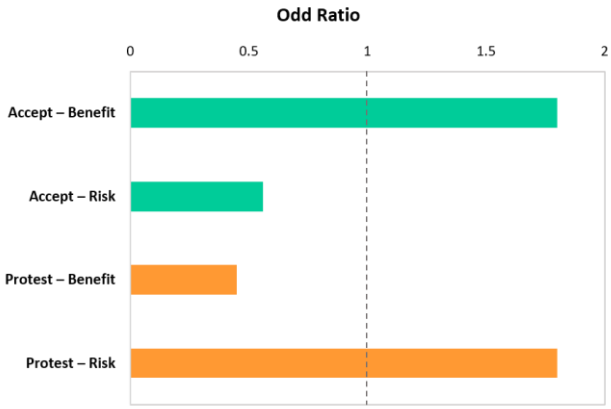

Fig.2. Regression Analysis Results (Benefit and Risk)

Perceived risk significantly increases the likelihood of protest (OR = 1.80, 95% CI: 1.38–2.38), while perceived benefit reduces the likelihood of protest (OR = 0.45, 95% CI: 0.35–0.57). The similar size of these effects suggests that acceptance and protest are not driven by different mechanisms. Instead, they reflect opposite responses within the same risk–benefit evaluation process. People who focus more on benefits are more likely to accept, whereas those who focus more on risks are more likely to protest.

In comparison, socio-demographic variables have smaller and less consistent effects. Although factors such as gender and education are statistically significant, their influence is relatively weaker and less systematic than that of perceptual factors. Overall, these findings indicate that public responses to urban SMRs are shaped mainly by how people evaluate risks and benefits, rather than by demographic differences.

4. Discussion

The findings provide practical implications for urban SMR deployment strategies. Public responses are primarily structured around a risk–benefit evaluation framework, consistent with prior research on nuclear acceptance. Acceptance increases as perceived benefits exceed perceived risks, whereas protest becomes more likely when perceived risks prevail. The strong effect of perceived benefit indicates that clearly communicating the tangible advantages of urban SMRs is essential, including contributions to carbon neutrality, local economic development, energy security, and grid stability. At the same time, perceived risk remains a key driver of protest, suggesting that transparent communication about safety design and regulatory oversight may help reduce heightened risk perception. Socio-demographic analysis further shows that protest is not confined to a specific age, income, or education group. Rather, opposition appears to be broadly associated with evaluative perceptions rather than fixed demographic characteristics.

This suggests that effective communication strategies extend beyond demographic targeting and concentrate on core perceptual variables. Engagement efforts that enhance the visibility of benefits while addressing perceived risks are likely to be more effective in fostering social acceptance of urban SMR siting.

5. Conclusion

This study examined the perceptual structure underlying acceptance and protest toward urban SMR siting within a control-group setting. The results demonstrate that public responses are primarily organized around a risk–benefit trade-off. Perceived benefit increases acceptance, while perceived risk increases protest, indicating that support and opposition emerge from a common evaluative framework. The findings also suggest that urban SMR debates are not simply driven by demographic segmentation but by how residents assess the balance between expected advantages and potential risks in densely populated environments.

As urban deployment introduces unique contextual sensitivities such as proximity, multi-dimensional nuclear perception, and local externalities, understanding perceptual mechanisms becomes particularly important [4]. While this study focuses on perceived benefit and risk as core determinants, future research should expand the analytical scope to incorporate a broader range of perceptual factors relevant to urban settings. These may include trust in institutions, fairness, environmental values, and technology-specific affective responses. Moreover, further investigation is needed to examine the structural relationships among these perceptual variables, including direct, mediated, and indirect effects. Such analyses would help identify the ultimate determinants that differentiate conditional acceptance from absolute opposition in urban SMR siting. A more comprehensive modelling approach may provide deeper insight into how urban residents form stable acceptance or protest positions in the context of next-generation nuclear technologies.

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