Validating Behavioural Model of Rational Choice for Net Zero Manufacturing: An Action Research Approach

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Abstract. Herbert Simon introduced the behavioural model of rational choice in 1955, challenging traditional economic assumptions by acknowledging that decision-makers face cognitive limitations, time constraints, and incomplete information, leading them to seek satisficing solutions that are adequate rather than optimal. This paper presents the methodological approach and findings from an action research study conducted to validate the behavioural model of rational choice for net zero manufacturing framework. The research was implemented at a leading UK manufacturing research and development centre specialising in transformative manufacturing technologies. The primary aim was to understand whether this framework can help overcome contributing elements of bounded rationality—complexity, information asymmetry, and cognitive biases—that typically hinder net zero strategic decision-making in manufacturing contexts. The action research methodology enabled framework refinement while simultaneously supporting the organisation's net zero objectives. Data collection involved stakeholder interviews, process documentation, and outcome assessments. This paper contributes to the understanding of strategic decision-making in net zero manufacturing contexts and provides methodological insights for framework validation in industrial settings.

Keywords: action research · bounded rationality · cognitive biases · decision-making frameworks · framework validation · information asymmetry · net zero complexity · net zero strategy

1 Introduction

The transition to net zero emissions by 2050 represents a critical pathway for ensuring both environmental sustainability and business continuity globally [1]. Despite widespread climate commitments from countries and businesses, a persistent execution gap exists between ambitious pledges and concrete actions [2]. This disconnect raises fundamental questions about organizational decision-making in the face of climate imperatives. Manufacturing organizations navigating net zero transformations encounter

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three primary challenges: complexity in developing decarbonization strategies [3–5], information asymmetry regarding emissions data and technology performance [6, 7], and cognitive biases that distort strategic decisions [8–10]. These challenges align with Herbert Simon's concept of bounded rationality [11], which explains how decision-makers operate with cognitive constraints, incomplete information, and organizational complexities. Simon's 1953 - behavioural model of rational choice outlines six key elements needed to overcome bounded rationality-complete set of decisions, the subset of behavioural alternatives to be considered, values assessment through a pay-off function, use of probability and information assessment [12].

Existing models for net zero manufacturing transformation exhibit limitations. Technology-focused approaches assume perfect rationality among stakeholders and overlook behavioural challenges [13]. Integrated organizational and technological frameworks fail to capture the complex interrelationships between stakeholders [14]. Industry-specific models lack broader applicability, while practical roadmaps often rely on optimistic technological assumptions while underestimating barriers [15]. A notable shortcoming across many frameworks is inadequate attention to social and behavioural dimensions, including resistance to change and stakeholder engagement strategies.

To address these gaps, behavioural model of rational choice for net zero manufacturing was developed that integrates bounded rationality theory with practical manufacturing expertise. The model is structured around seven core decision categories: leadership and strategy, risk and performance measurement, organizational structure and culture, communication and awareness, measurement and reporting, collaboration and partnerships, and training and skill development. Each category contains hierarchically organized behavioural alternatives supported by three assessment components: information assessment, pay-off assessment, and probability assessment. This research reports the results of Phase I of action research study conducted to validate this framework within a leading UK manufacturing technology centre during their net zero strategy development.

2 Behavioural Model of Rational Choice for Net Zero Manufacturing

The behavioural model of rational choice for net zero manufacturing as shown below in Fig. 1 integrates theoretical principles with practical insights to address the strategic decision-making challenges manufacturers face during decarbonization.

The framework is structured around seven core decision categories, and each decision category contains behavioural alternatives organized hierarchically to guide progressive implementation based on organizational maturity. The model was developed through a comprehensive triangulation methodology that integrated theoretical foundations with industry expertise, the details of which have been discussed in previous work [16].

The framework directly applies Herbert Simon's bounded rationality theory by incorporating all six elements of his behavioural model of rational choice. First, it maps the complete set of behavioural alternatives available within each decision category, providing decision-makers with comprehensive options. Second, recognizing cognitive limitations, it focuses decision-makers on alternatives based on their current maturity levels, allowing progressive implementation of higher-impact practices rather than overwhelming attempts to implement all alternatives simultaneously.

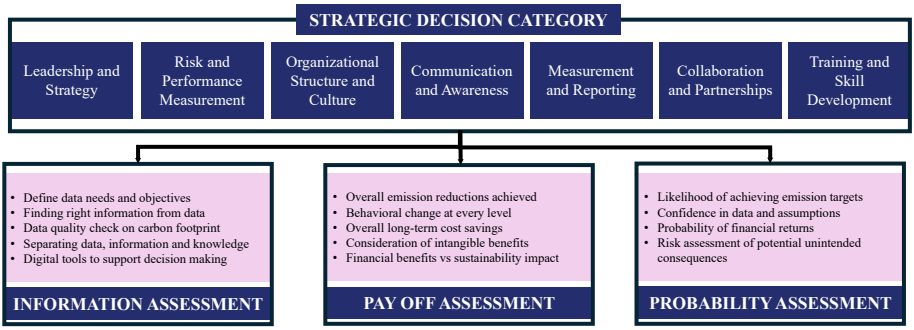


Fig. 1. Behavioural model of rational choice for net zero manufacturing

Third, the model incorporates a pay-off assessment component evaluating actual and potential benefits of net zero decisions, quantifying both tangible outcomes like emission reductions or cost savings and intangible benefits like relationship improvements or sustainability impact. This structured evaluation helps overcome the cognitive challenge of assigning appropriate values to different outcomes that Simon identified in his pay-off function concept. Fourth, the framework addresses incomplete information through its information assessment component, helping organizations define data needs, ensure quality checks on carbon footprints, extract meaningful information from available data, and differentiate between data, information, and knowledge. This systematic approach to information management reduces information asymmetry and improves decision quality. Finally, the probability assessment component provides structured probability distributions essential for rational choice under uncertainty. By evaluating confidence in data assumptions, likelihood of achieving emission targets, probability of financial returns, and risk assessment of potential unintended consequences, this element helps decision-makers manage uncertainty systematically.

3 Framework Validation Methodology

This study employed action research methodology to simultaneously validate the framework and apply it practically [17]. Action research was chosen for its ability to generate knowledge while addressing real organizational challenges, appropriate for understanding framework functionality in real-world settings while contributing to strategic objectives. The cyclical process of planning, action, observation, and reflection enabled continuous framework refinement, creating a dynamic validation process responsive to emerging insights. This participatory approach involved organizational stakeholders as active participants, addressed concrete challenges, allowed iterative refinement, acknowledged the unique organizational context, and facilitated transformation. The study was conducted at a leading UK manufacturing research and development centre developing its internal net zero strategy, providing an ideal context for framework application. The research period involved collaboration with the sustainability team, senior management, and operational departments, applying the framework to guide the development of their

net zero strategy. Data collection included semi-structured interviews with key stakeholders; process documentation through field notes, meeting minutes, feedback sessions; and outcome assessment using predetermined validation criteria. Model effectiveness was systematically evaluated using four-dimensional validation criteria - workability, transferability, catalytic validity, and process validity, each assessed on a 5-point Likert scale through researcher observation and participant evaluation. Workability assesses the framework's practical implementation feasibility, transferability evaluates its adaptability across different manufacturing contexts, catalytic validity measures its ability to stimulate meaningful organizational change, and process validity examines the methodological robustness of the implementation approach. These criteria were selected based on established action research validation principles that emphasize practical application and transformative potential in organizational contexts [17]. The company is currently adapting this framework to develop their internal net zero strategy, with implementation efforts being collaboratively conducted between two teams. One team is specifically responsible for creating the strategy internally, while the second team oversees broader sustainability initiatives across the organization. The overall plan is divided into four phases as shown below in Fig. 2.

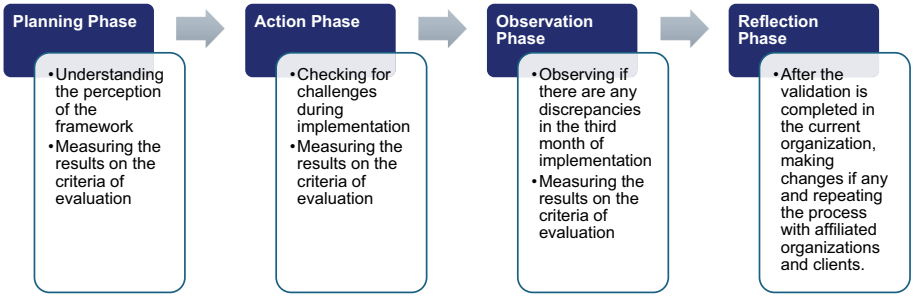


Fig. 2. Overall validation plan

4 Discussion

The results of Phase I are presented below in this research work, and they provide principal validation of the framework and sets the foundation for comparing the results of the same with other phases.

With a workability score of 4/5, the framework demonstrated promise of strong practical utility in guiding strategic decision-making processes. Participants particularly valued the structured approach to breaking down complex decisions and the explicit consideration of cognitive biases. The framework achieved a perfect transferability score of 5/5, showing potential for application in other manufacturing contexts. Its modular structure facilitated adaptation to specific circumstances across different departments and decision types. Participants identified that the principles extended beyond net zero decisions, with potential applications in technology investment and operational strategy decisions. For catalytic validity, the framework scored 4/5, demonstrating strong ability to stimulate action and change within the organization. The bias mitigation components

proved particularly effective in challenging status quo thinking and encouraging innovative approaches to decarbonization. The framework successfully transformed abstract net zero commitments into concrete action plans with clear responsibilities and timelines. Process validity also received a score of 4/5, with the quality of decision-making processes facilitated by the framework consistently rated as high. Participants reported promise of increased confidence in their decisions and greater awareness of potential blind spots. The structured processes helps ensure comprehensive consideration of relevant factors and stakeholder perspectives.

The framework addresses the three main elements of bounded rationality. For complexity management, the hierarchical organization of decision categories and behaviour alternatives could potentially reduce cognitive overload by breaking down the net zero challenge into manageable components. Regarding information asymmetry reduction, the framework's emphasis on measurement, reporting, and information quality assessment addressed information gaps. By establishing clear data needs, implementing quality checks, and distinguishing between information, data, and knowledge, the framework could improve information access and quality across cross functional stakeholders. For cognitive bias mitigation, the framework's explicit consideration of cognitive biases could help participants recognize and counteract these tendencies. Training on bias awareness, combined with structured decision processes, could reduce the impact of common biases such as status quo bias and optimism bias. The framework could potentially contribute to the organization's net zero strategic planning process, leading to higher decision confidence, improved stakeholder alignment, more ambitious carbon reduction targets than initially planned, and accelerated implementation of net zero initiatives.

Key learnings from this initial validation include the importance of customizable assessment components to accommodate varying organizational maturity levels, the necessity of integrating the framework with existing strategic planning processes rather than operating in isolation, and the value of cross-functional stakeholder involvement to overcome departmental information asymmetries. The validation process also revealed opportunities for framework improvement, including the need for more detailed guidance on quantifying intangible benefits, developing more robust tools for bias identification in group decision-making contexts, and creating simplified versions for smaller manufacturing organizations with limited resources.

5 Conclusion

This study validated a behavioural model of rational choice for net zero manufacturing through phase I of action research methodology. The framework effectively addresses bounded rationality challenges in strategic decision-making by tackling complexity, information asymmetry, and cognitive biases. Performance across workability, transferability, catalytic validity, and process validity criteria demonstrates its value in supporting manufacturing organizations navigating the transition to net zero operations.

However, limitations of the current study should be acknowledged. The validation was conducted in a single organization, limiting the generalizability of findings, as different manufacturing sectors may face unique challenges that require framework adaptation. The timeframe, while sufficient for initial validation, did not allow for assessment

of long-term outcomes, leaving the sustained effectiveness of the framework over time undetermined. The researchers' dual roles as framework developers and validation facilitators may have introduced potential bias. While efforts were made to maintain objectivity, this limitation should be considered when interpreting results. The validation focused primarily on perceptions rather than implementation, indicating additional research is needed to assess the framework's effectiveness throughout the implementation process.

Future research will continue with phases II-IV of the validation plan with the partner company, progressively evaluating the framework's effectiveness in strategy implementation, measuring outcomes against established key performance indicators, and assessing long-term impacts on carbon reduction and business performance. These subsequent phases will provide data on how the framework functions throughout the complete net zero transformation journey, from strategy development through implementation to outcome measurement. This will then allow to do a comparative analysis of the team's perception of framework value with the actual value delivered by the framework implementation. Additionally, validation studies should be expanded across a wider range of manufacturing contexts and organizational scales. Comparative studies examining different decision support frameworks could provide insights into their relative effectiveness in various manufacturing contexts.

Despite these limitations, the evidence suggests the behavioural model of rational choice for net zero manufacturing represents potential advancement in supporting manufacturing organizations to navigate the complexities of decarbonization while accounting for the cognitive and informational constraints of real-world decision-making.

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