

Uncovering Decision-Making Implications Across Building Owners: A Formal Concept Analysis of Building
Public and Private Owners.

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Abstract

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Owner organizations play a critical role in shaping decision-making processes during construction and project outcomes in the building construction sector, yet existing research has primarily examined decision-making characteristics as independent traits rather than as combinations within organizational contexts. This study addresses this gap by investigating the following two research questions: (1) whether public and private building owners exhibit distinct decision-making implications— configuration of characteristics that imply one another—and (2) whether any such implications are shared across ownership types.

Using survey data from 109 owner organizations collected as part of Phase 1 of the Building Owners Assessment Tool (BOAT) research program, the study applied formal concept analysis (FCA) and constructed formal contexts based on 22 Decision-Making Profile Characteristics (DMPC). Formal implications— representing decision-making configurations—were obtained using the Duquenne-Guigues basis separately for public and private owners. The analysis revealed substantial structural divergence between ownership types: the public-owner context produced 584 implications, the private-owner context produced 304, and only one was shared across both. This cross-sector implication linked relational participation, adaptive and informal decision-making styles, command and learning-oriented cultures, and a sustained-growth environment to data-driven decision-making.

The findings demonstrate that decision-making logic is highly context-dependent and largely non-transferable across ownership types, while also identifying an implication with a robust configuration that emerges under conditions of organizational complexity. By revealing the decision-making implications, this study advances theoretical understanding of organizational logic in construction management and demonstrates the value of configurational, logic-based methods for analyzing governance-driven differences in decision processes.

Table of Contents

Chapter 1. Introduction	7
Chapter 2. Literature Review.....	9
2.1 The Role of Owner Decision-Making in Construction.....	9
2.2 Understanding Decision-Making Characteristics in Owner Organizations	10
2.3 Public and Private Owners: Institutional Differences.....	12
2.4 Configurational understanding of Decision Making	14
2.4.1 Formal Concept Analysis as a Configurational Method.....	16
2.5 Research gap and approach.....	17
Chapter 3. Research Methodology	20
3.1 Research Design	20
3.1.1 Work Flow	21
3.2 Data Source.....	22
3.2.1 Data Preparation	23
3.3 Formal Concept Analysis.....	25
3.3.1 Formal Context Construction	25
3.3.2 Implication Extraction	26
3.4 Software and Implementation.....	26
Chapter 4. Results	28
4.1 Overview of Results.....	28
4.2 Structural divergence	29
4.2.1 Distinct Implication Structures	29
4.3 Cross-Sector Invariant Implication.....	30

4.3.1	Interpretation of Shared Implication	31
4.3.2	Meaning of Data-Driven Style as a Result	32
4.4	Implications with Data-Driven Style as a Result	32
4.4.1	Public sector and Data-Driven Style.....	33
4.4.2	Private Sector and Data-Driven Style.....	33
4.4.3	Comparison between Public and Private	34
Chapter 5.	Conclusion	36
Chapter 6.	Bibliography.....	38

Table of Figures

Figure 1	Methodology Workflow	22
Figure 2	BOAT Survey Demographics and project delivery methods used in their projects.	23
Figure 3	Results Overview	28
Figure 4	Cross Sector Implication; Left (A), Right (B)	31
Figure 5	Implications with Data Driven as a result (B) in the Public Owner Context.....	33
Figure 6	Implications with Data Driven as a result (B) in Private Owner Context	34

Chapter 1. Introduction

Owner organizations play a central role in shaping how building projects are conceived, constructed, and delivered. Beyond selecting project delivery methods or managing contracts, owners establish the decision-making environment that influences how they set priorities, manage risks, and assess performance. In construction, where projects are characterized by long schedules, multiple stakeholders, and high levels of uncertainty, owner decision-making significantly impacts project outcomes and organizational learning (Wu and AbouRizk, 2023).

Research in construction management and organizational studies has consistently emphasized the central role of owner organizations in shaping project outcomes. Studies of owner capabilities identify a broad set of characteristics—including strategic, commercial, governance, coordination, and dynamic capabilities—that contribute to project success (G. Winch and Leiringer 2016; Zhang et al. 2023). Similarly, industry research has linked owner involvement and organizational capacity to improved performance outcomes. Prior work also highlights that owner organizations operate under differing institutional and governance conditions, which influence how decisions are structured and implemented within projects (G. Winch and Leiringer 2016).

Despite this extensive body of research, less is known about how the decision-making characteristics of building construction owners combine and interact across different organizational contexts. Existing studies have primarily examined individual characteristics, focusing on their independent associations with project outcomes rather than on how they co-occur within organizations (Zhang et al. 2023). Consequently, prior research does not reveal whether owners rely on distinct patterns of relationships among decision-making characteristics or whether certain relationships are shared across contexts. Furthermore, construction management research has made limited use of logic-based methods capable of identifying structural relationships and dependencies among these characteristics.

To address this research gap, we applied formal concept analysis (FCA) to the Decision Making Profile Characteristics (DMPC), a portion of the survey data collected through Building Owners Assessment Tool

(BOAT) research (<https://boat.be.uw.edu/>). We examined the DMPCs as configurations of characteristics rather than as isolated traits. This approach systematically examines relationships among decision-making characteristics across ownership types and identifies configurations—groupings of characteristics—that imply one another and remain stable across organizational contexts. Specifically, the research questions were as follows: (1) Do public and private building owners exhibit distinct decision-making implications, and (2) What decision-making implications, if any, are shared across ownership types?

The analysis revealed substantial differences in implication sets across owner contexts, indicating a structural divergence in how decision are taken. Only a single implication was shared across contexts, linking relational participation, adaptive and informal decision styles, command and learning-oriented cultures, and a sustained growth environment to data-driven decision-making. In addition, analysis of implications with data-driven decision-making as the consequent showed distinct patterns across contexts: Implications in one context tended to cluster around similar sets of antecedent characteristics, while implications in the other exhibited greater variation in the combinations of attributes leading to data-driven outcomes. These findings suggest that while most decision-making relationships are context-dependent, certain implications may emerge consistently, and that similar outcomes can be achieved through structurally different pathways.

Chapter 2. Literature Review

2.1 The Role of Owner Decision-Making in Construction

Owner organizations play a central role in shaping the outcomes of construction projects, particularly in complex and large-scale developments. Prior research identifies owners as both the primary investors and, in many cases, the long-term operators of constructed assets, positioning them as key decision-makers throughout the project lifecycle (G. Winch and Leiringer 2016; G. M. Winch 2014). Despite this centrality, the role of the owner in decision-making in the construction process has often been underexplored, with greater attention traditionally placed on contractors, designers, and project delivery mechanisms (Zhang et al. 2023).

Recent studies emphasize that project success is closely linked to the organizational capabilities of owners. These capabilities extend beyond financial investment and include the ability to coordinate multiple stakeholders, align project objectives with long-term strategic goals, and govern complex interorganizational relationships (Zhang et al. 2023). Among these, coordination capabilities have been identified as particularly critical, as construction projects involve a wide range of actors—including designers, contractors, consultants, suppliers, and regulatory bodies—whose activities must be effectively integrated. (Zhang et al. 2023). The complexity inherent in these multi-actor environments places significant demands on owners to manage interfaces and resolve conflicts across organizational boundaries.

In addition to coordination, owner capabilities can be understood across several interrelated dimensions, including strategic, commercial, and governance capabilities (Stordy et al. 2021). Strategic capabilities enable owners to prioritize and select projects aligned with long-term organizational objectives, particularly in environments characterized by competing investment opportunities. Commercial capabilities relate to contractual arrangements and the structuring of relationships with suppliers, often influencing how project risks and responsibilities are distributed. Governance capabilities, in turn, define how oversight, control, and accountability are exercised across both the permanent organization and the temporary project structure (Stordy et al. 2021).

Importantly, construction projects operate within a broader organizational context in which permanent owner organizations interact with temporary project organizations. This interface requires mechanisms to align strategic intent with project execution, as well as governance structures to coordinate activities across organizational boundaries (Stordy et al. 2021). The increasing “projectification” of economic activity further reinforces the importance of understanding how owner organizations manage these relationships, as projects become a primary means through which organizations deliver strategic value.

While this literature provides valuable insights into the types of capabilities required by owners, it predominantly conceptualizes these capabilities as discrete dimensions (G. Winch and Leiringer 2016; Zhang et al. 2023). Less attention has been given to how these capabilities—and the underlying decision-making characteristics—interact within organizational contexts. As a result, there remains limited understanding of how owner decision-making is structured as a system of interrelated characteristics, particularly in relation to how these relationships may influence project outcomes.

2.2 Understanding Decision-Making Characteristics in Owner Organizations

Decision-making within owner organizations is not a linear or uniform process but is shaped by a combination of organizational, contextual, and decision-specific factors. Research on strategic decision-making emphasizes that decisions emerge from the interaction of environmental conditions, organizational structures, managerial characteristics, and the nature of the decision itself (Papadakis et al. 1998). This perspective highlights that decision-making processes vary across organizations and situations, as the same internal or external stimulus may be interpreted differently depending on the context and the actors involved. As a result, decision-making is dynamic and subject to change in different scenarios rather than standardized.

Organizational context plays a fundamental role in shaping how decisions are made. Differences in organizational purpose, stakeholder expectations, and accountability structures influence how problems are defined and how alternatives are evaluated (Nutt 2006). Decision-makers operate within environments that impose varying levels of constraint, including resource limitations, regulatory requirements, and

external pressures. These contextual conditions shape both the availability of information and the processes through which decisions are developed.

The environments in which organizations operate further influence decision-making practices by affecting the availability and clarity of information. In some settings, decision-makers may have access to extensive data and analytical tools to support structured evaluation of alternatives, while in others, information may be incomplete, ambiguous, or difficult to obtain (Nutt 2006). Additionally, varying levels of oversight and external scrutiny can influence how decisions are documented, justified, and communicated. These environmental conditions contribute to differences in how organizations approach uncertainty and evaluate potential courses of action.

Within project-based environments, decision-making is further shaped by organizational structures and governance arrangements. Owners operate across both permanent organizational entities and temporary project organizations, requiring mechanisms to align long-term strategic objectives with project execution (G. M. Winch 2014). Governance processes, including project selection, resource allocation, and performance monitoring, play a central role in coordinating activities across these structures. These arrangements introduce additional complexity, particularly in contexts where organizations engage in projects intermittently and rely on external actors to support project delivery.

In addition to contextual and organizational influences, the characteristics of individual decisions themselves affect how decision-making processes unfold. Strategic decisions vary in terms of uncertainty, urgency, and complexity, and these differences influence the processes through which decisions are identified, evaluated, and implemented (Papadakis et al. 1998). The same issue may be approached differently depending on how it is interpreted by decision-makers, further reinforcing the variability of decision processes.

Taken together, these perspectives indicate that decision-making in owner organizations is shaped by a combination of contextual conditions, organizational structures, decision-making practices, and decision-

specific characteristics. These dimensions interact to produce varied and dynamic decision processes across organizational settings

2.3 Public and Private Owners: Institutional Differences

Public and private owner organizations differ fundamentally in their institutional foundations, particularly in terms of ownership, funding, and control. Public organizations are typically owned collectively and operate as instruments of political communities, while private organizations are owned by individuals or shareholders and are driven by market forces (Boyne 2002). These distinctions are further reinforced by differences in funding mechanisms—public organizations relying largely on taxation and private organizations on revenue generation—as well as by the dominant forms of control, which are political in the public sector and economic in the private sector. Rather than representing a strict dichotomy, these characteristics can be understood along a spectrum of “publicness,” where organizations exhibit varying degrees of public and private attributes depending on their context and function (Boyne 2002).

One of the most widely discussed differences between public and private organizations concerns their goals. Public organizations are often characterized as having multiple, ambiguous, and sometimes conflicting objectives, reflecting the diverse and value-laden demands placed upon them by stakeholders and political actors (Rainey and Bozeman 2000). In contrast, private organizations are typically associated with clearer and more measurable goals, such as profitability and market performance. However, empirical research presents a more nuanced picture. Surveys of managers across sectors indicate that public managers often perceive their organizational goals as relatively clear and measurable, challenging common assumptions about goal ambiguity in the public sector (Rainey and Bozeman 2000). This divergence between theoretical expectations and managerial perceptions highlights the complexity of goal structures and suggests that differences may lie not only in the goals themselves but also in how they are interpreted and operationalized.

The external environments in which public and private organizations operate also differ significantly, shaping the constraints and opportunities for decision-making. Public organizations function within highly

complex and politically influenced environments, where multiple stakeholders impose competing demands and where organizational boundaries are more permeable to external influence (Boyne 2002). These environments are often characterized by instability due to shifting political priorities and policy cycles, as well as by an absence of strong competitive pressures, which encourages collaboration rather than competition among organizations. In contrast, private organizations operate in market-driven environments where competition plays a central role in shaping strategy and performance, and where external pressures are primarily economic rather than political.

Differences between public and private organizations are also reflected in their internal structures and levels of formalization. Public organizations are frequently described as more bureaucratic, with greater reliance on formal procedures, rules, and control mechanisms, often justified by the need for accountability and transparency (Boyne 2002). These characteristics are commonly associated with the concept of “red tape,” referring to excessive or burdensome formalization. However, empirical findings on this issue are mixed, with some studies finding little difference between public and private organizations in terms of formalization (Rainey and Bozeman 2000). This suggests that while bureaucratic structures are a defining feature of public organizations in theory, their practical manifestation may vary across contexts.

Managerial autonomy represents another key area of distinction. Managers in public organizations typically operate under greater constraints due to oversight mechanisms, political accountability, and the need to justify decisions to multiple external actors (Boyne 2002). These constraints can limit flexibility and increase the need for compliance with established procedures. In contrast, managers in private organizations generally have greater discretion to make decisions and implement strategies, supported by hierarchical structures that enable more direct control over resources and operations. These differences in autonomy influence how decisions are initiated, evaluated, and executed within organizations.

These institutional differences translate into distinct decision-making behaviors and practices. Public organizations tend to emphasize collaboration, negotiation, and stakeholder engagement, reflecting the need to balance competing interests and maintain legitimacy within a politically charged environment (Nutt 2006). Decision-making processes in these contexts often involve consultation and consensus-building,

particularly when multiple stakeholders are affected. In contrast, private organizations are more likely to prioritize analytical approaches, efficiency, and competitive positioning, relying on data-driven evaluations and internal decision-making processes. These differences illustrate how institutional context shapes not only the constraints on decision-making but also the preferred approaches to evaluating and selecting alternatives.

In construction contexts, these differences are reflected in how owner organizations define project objectives and select delivery strategies. Owners may pursue a range of goals when selecting project delivery methods, including cost savings, schedule reduction, innovation, and risk allocation (Lopez Del Puerto et al. 2008). The relative importance of these goals can vary depending on the organizational context, influencing the criteria used to evaluate project alternatives and the structure of contractual relationships. For example, the adoption of design–build approaches may be motivated by the desire to integrate design and construction responsibilities, improve efficiency, and enhance innovation, reflecting the priorities of the owner organization.

Taken together, the literature indicates that public and private owner organizations differ across multiple dimensions, including their institutional foundations, goal structures, external environments, internal governance mechanisms, and managerial practices. These differences shape the conditions under which decisions are made and influence how organizations approach the planning and execution of construction projects.

2.4 Configurational understanding of Decision Making

Existing research on decision-making in organizations has largely focused on identifying individual characteristics that influence how decisions are made, such as organizational structure, environmental conditions, and managerial styles. Much of this work adopts a variable-based approach, examining the independent effects of specific factors on decision outcomes. For example, Dean and Sharfman (1997) analyze how procedural rationality influences decision effectiveness, emphasizing the role of structured, analytical processes. Similarly, Eisenhardt and Zbaracki (1992) review strategic decision-making research

and highlight the dominance of approaches that isolate variables such as rationality, power, and environmental conditions. While these studies provide valuable insights, they tend to treat decision-making characteristics as discrete elements rather than as part of an interconnected system.

Configurational perspectives offer an alternative approach by emphasizing the importance of interactions among multiple organizational elements. Meyer, Tsui, and Hinings (1993) argue that organizations are best understood as holistic systems composed of interdependent attributes that form coherent patterns. Rather than focusing on single variables, their work highlights how combinations of organizational characteristics create distinct configurations that shape outcomes. Building on this perspective, Fiss (2007) introduces a configurational approach to organizational research that emphasizes the existence of multiple, equally effective combinations of conditions, a concept referred to as equifinality. This approach challenges the assumption that there is a single optimal set of characteristics, instead recognizing that different configurations can produce similar outcomes depending on the context.

Earlier work by Miller (1986) further supports the configurational perspective by demonstrating that organizations tend to exhibit internally consistent patterns of attributes, which he describes as configurations. Miller argues that these configurations arise from the alignment of organizational elements such as strategy, structure, and environment, and that such alignment is critical for organizational effectiveness. Similarly, Doty, Glick, and Huber (1993) examine organizational typologies and show that configurations represent theoretically meaningful combinations of attributes rather than arbitrary groupings. Their work reinforces the idea that understanding organizations requires analyzing how multiple characteristics co-occur and interact, rather than examining variables in isolation.

Configurational thinking has important implications for understanding decision-making processes. As discussed in previous sections, decision-making in owner organizations is influenced by a range of factors, including contextual conditions, organizational structures, governance mechanisms, and decision-specific characteristics. These factors do not operate independently; instead, they interact in ways that shape how decisions are defined, evaluated, and implemented. For instance, the effect of organizational structure on decision-making may depend on environmental uncertainty, while the role of decision-making style may

vary depending on governance arrangements and stakeholder expectations. This interdependence suggests that decision-making is inherently relational and cannot be fully understood through variable-based approaches alone.

Fiss (2011) further develops the configurational perspective by emphasizing the importance of identifying patterns of attribute combinations that consistently co-occur across cases. He argues that such patterns reveal underlying structures that are not apparent when variables are analyzed independently. By focusing on these configurations, researchers can better capture the complexity of organizational phenomena and recognize that different pathways may lead to similar outcomes. This perspective is particularly relevant for analyzing decision-making in complex organizational settings, where multiple factors interact simultaneously.

The shift toward a configurational perspective also has methodological implications. Meyer, Tsui, and Hinings (1993) note that traditional statistical methods, which focus on estimating the net effects of independent variables, are limited in their ability to capture interactions among multiple attributes. As a result, there is a need for analytical approaches that explicitly model combinations of conditions and their relationships. Such methods enable the identification of patterns of co-occurrence and dependency, providing a more comprehensive understanding of complex organizational processes.

2.4.1 Formal Concept Analysis as a Configurational Method.

Formal Concept Analysis (FCA) provides a rigorous mathematical framework for analyzing relationships between objects and attributes and for identifying structured patterns within data (Ganter et al. 2005). At its core, FCA is based on representing data as a binary relation between a set of objects and a set of attributes, where each object is described by the attributes it possesses. This structure enables the systematic exploration of how attributes are distributed across objects and how they relate to one another.

A central concept in FCA is the notion of a formal concept, defined as a pair consisting of a set of objects (extent) and a set of attributes (intent) that are shared by those objects (Ganter et al. 2005). These concepts

can be organized into a concept lattice, which represents the hierarchical relationships among concepts based on set inclusion. The lattice structure provides a comprehensive view of the relationships between objects and attributes, revealing how attributes cluster and how different combinations of attributes are related.

Beyond the identification of concepts, FCA enables the derivation of implications, which are conditional statements of the form “if A, then B,” indicating that whenever a set of attributes A is present, another set of attributes B is also present. These implications represent deterministic relationships within the data and differ from probabilistic associations in that they hold universally for the observed cases. The set of all valid implications can be represented by a canonical basis, most commonly the Duquenne–Guigues basis, which provides a minimal, non-redundant, and complete set of implication rules (Guigues 1986; Kuznetsov and Obiedkov 2002)

FCA has been applied in a variety of domains, including knowledge discovery, data analysis, and classification, where it is used to identify patterns and relationships that are not readily observable through traditional statistical methods (Poelmans et al. 2013). Its ability to reveal structured relationships among attributes makes it particularly suitable for analyzing complex systems characterized by multiple interacting components.

In the context of organizational decision-making, FCA offers a means to examine how decision-making characteristics are related to one another and to identify configurations of attributes that consistently co-occur. By focusing on relationships and dependencies rather than isolated variables, FCA provides a configurational lens through which decision-making processes can be analyzed in a systematic and interpretable manner.

2.5 Research gap and approach

The literature reviewed in this chapter highlights several important insights regarding decision-making in construction and organizational contexts. Prior research establishes the central role of owner organizations

in shaping project outcomes and emphasizes the importance of organizational capabilities in managing complex projects. It also demonstrates that decision-making processes are influenced by a range of factors, including organizational structures, environmental conditions, and decision-specific characteristics. Furthermore, studies comparing public and private organizations reveal systematic differences in institutional contexts, goal structures, governance arrangements, and managerial practices.

Despite these contributions, existing research has primarily examined decision-making characteristics as discrete dimensions, often focusing on the independent effects of individual variables. As a result, limited attention has been given to how these characteristics combine within organizations to form structured patterns of decision-making. In particular, the relationships among decision-making attributes and the ways in which they jointly shape decision processes remain underexplored.

This limitation is especially relevant in the context of comparing public and private owner organizations. While prior studies document differences in decision-making practices across sectors, they do not examine whether these differences extend to the underlying relationships among decision-making characteristics. It remains unclear whether public and private organizations exhibit distinct configurations of attributes or whether certain patterns of relationships are shared across contexts.

In addition to this conceptual gap, there is a methodological limitation in the existing literature. Most studies rely on approaches that focus on isolated variables or linear relationships, which are not well suited to capturing the complexity of interactions among multiple attributes. As a result, there is a need for analytical methods that can identify patterns of co-occurrence and dependency among decision-making characteristics.

To address these gaps, this study adopts a configurational approach to analyze decision-making in owner organizations. Using Formal Concept Analysis, the study examines the relationships among decision-making attributes and identifies implication structures that capture how these attributes are associated within and across organizational contexts. This approach enables a systematic analysis of decision-making

as a set of interrelated characteristics, providing new insights into the structure of decision-making processes in construction.

Chapter 3. Research Methodology

3.1 Research Design

This study uses an exploratory, configurational research design to examine how decision-making characteristics combine within owner organizations in the construction industry. Rather than analyzing attributes in isolation, the study focuses on identifying structured combinations of characteristics and their conditional relationships, addressing the research questions through a set-theoretic analytical lens.

The methodological approach is grounded in Formal Concept Analysis (FCA), a mathematical framework originally developed by Rudolf Wille (1982), which enables the systematic analysis of relationships between a set of objects and their attributes. FCA has been applied across disciplines to uncover hidden conceptual structures and implication relationships within complex datasets. Prior research has used FCA to identify conceptual groupings and logical dependencies in domains such as knowledge discovery, information systems, and marketing analytics, where understanding how attributes co-occur is central to interpretation.

Importantly, FCA has also been applied in marketing and consumer research to construct consumer profiles based on shared attribute configurations. In these contexts, FCA enables the identification of groups of consumers characterized by common traits, as well as the extraction of implication rules that describe consistent relationships among attributes. This study draws on that logic by conceptualizing construction owners as decision-making actors whose organizational characteristics can be analyzed analogously to consumer profiles. Just as consumer behavior can be understood through combinations of preferences and traits, owner organizations can be examined through configurations of decision-making characteristics that jointly shape their behavior.

Within this framework, FCA is particularly well suited to the present study because it enables the identification of implication relationships of the form “if A, then B,” where A and B represent sets of decision-making attributes. These implications reflect systematic co-occurrence patterns that hold across the dataset, providing insight into how certain organizational characteristics consistently relate to others. Unlike statistical approaches that emphasize correlation or variable significance, FCA reveals deterministic

relationships within a defined context, allowing for a more structured understanding of how decision-making characteristics combine.

Important to mention that this study does not seek to establish causal relationships or probabilistic associations. Instead, it aims to uncover context-dependent logical structures within the data, focusing on how decision-making characteristics are organized within owner organizations and how these structures differ across ownership types. This approach aligns directly with the research objectives by enabling a comparison of implication structures between public and private owners, as well as the identification of any shared implications across contexts.

3.1.1 Work Flow

The workflow begins with survey data collected from owner organizations previously done by the BOAT original team, where decision-making characteristics are measured using Likert-scale responses. These responses are now transformed through binarization into binary indicators representing the presence or absence of each characteristic, allowing the construction of a formal context consistent with FCA requirements.

To enable comparative analysis, the dataset is separated into public and private owner organizations, with each subset treated as an independent formal context. FCA is then applied to each context to extract implication sets using the Duquenne–Guigues basis. These implications (if A, then B) represent systematic co-occurrence relationships among attributes within each ownership group.

The resulting implication structures serve as the primary analytical output and form the basis for comparing how decision-making characteristics are configured across public and private contexts. Through this workflow, the study systematically derives formal representations of decision-making implications, enabling a structured and context-sensitive analysis of owner organizations.

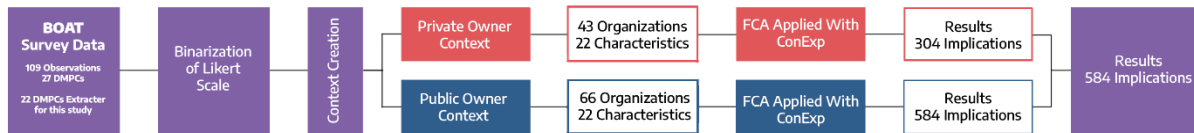


Figure 1 Methodology Workflow

3.2 Data Source

The data used in this study originates from the Building Owners Assessment Tool (BOAT), a research initiative developed at the University of Washington to examine how owner decision-making characteristics influence construction project outcomes. The BOAT framework was designed to identify key organizational attributes related to decision-making structures, processes, and cultures, and to support alignment between owner organizations and project delivery methods. (Dossick et al., n.d.)

The dataset consists of survey responses collected from building owner organizations in the construction industry. Each response represents an individual organization and captures a range of decision-making characteristics across multiple dimensions, including organizational structure, decision-making processes, cultural orientation, flexibility, and external environment. These characteristics reflect how owners approach planning, coordination, and execution in construction projects, providing a structured representation of organizational decision-making behavior.

The BOAT survey instrument was developed to enable owners to reflect on their internal decision-making profiles and their alignment with different project delivery strategies. As such, the data captures not only individual attributes but also the broader configuration of characteristics that shape organizational behavior. This makes the dataset particularly suitable for a configurational analysis approach, where the focus is on how attributes combine rather than how they operate independently.

3.2.1 Data Preparation

A total of 278 survey responses were collected through the BOAT survey. Of these, 109 responses were complete and deemed suitable for analysis, comprising 66 public organizations (61%) and 43 private organizations (39%), as shown in *Figure 2*, providing a balanced foundation for cross-sector comparison. In addition to ownership type, the sample captures variation in project delivery methods, reflecting the diversity of procurement approaches used in building construction. These include commonly adopted methods such as Design–Bid–Build, Construction Management at Risk, and Design–Build, among others. The inclusion of multiple delivery methods enhances the representativeness of the dataset and allows for a more comprehensive understanding of how decision-making characteristics manifest across different organizational and project contexts. Together, the distribution of ownership types and delivery approaches supports the study’s objective of examining how decision-making implications vary across institutional settings while remaining grounded in real-world project practices.

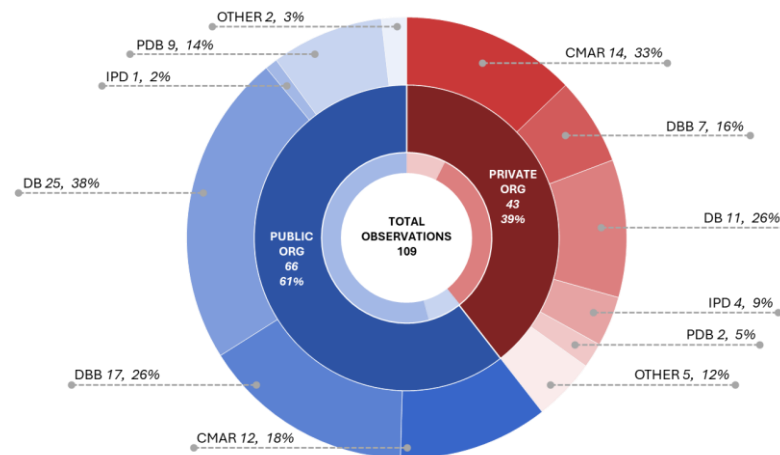


Figure 2 BOAT Survey Demographics and project delivery methods used in their projects.

The original survey included 89 variables capturing various aspects of organizational characteristics. Among these, 26 variables corresponded to DMPC's. For the purposes of this study, four demographic DMPC variables were excluded, as they are discrete in nature and do not meet the requirements for Formal Concept Analysis, which relies on binary attribute representation and conceptual relationships among characteristics.

The remaining 22 DMPC variables were retained and used to represent the decision-making profiles of owner organizations. These variables span multiple dimensions of organizational decision-making, including decision-making distribution, style, Culture, flexibility, risk tolerance, and the external environment. The full list of selected DMPC variables is provided in Table 1.

Table 1 DMPCs included in this research

Category	DMPC Name	DMPC Description
Decision Distribution	Authority Dispersion	Distribution of decision-making power across the organization
	Authority Delegation	Technical experts' authority to make decisions independently
	Process Informal Communication	Level of informal communication and talking
	Process Informal Procedure	Flexibility with rules and procedures
Decision Style	Data Driven	Reliance on numbers and data for decisions
	Participation Inclusion	Breadth of employee participation in decision-making
	Participation Relational	Importance of personal relationships at work
	Adaptive Informal	Level of informal management and coordination
	Adaptive Changeable	Organizational speed in adapting to new situations
	Authoritative Threats	The manager uses threats to achieve compliance
Organizational Culture	Authoritative Compliance	Managers use punishment to enforce rules
	Command	Top management has control over all major decisions
	Symbolic	Shared mission and values guiding decisions
	Formal	Adherence to formal rules and systems
	Experimental	Encouragement of innovation and new ideas
Flexibility	Learning	Focus on collaborative learning from others
	Open To New Ideas	Openness to new ideas from outside sources
Risk Tolerance	Open To Changes	Comfort with changing decisions and direction
	Risk Tolerance	Willingness to take big risks for big rewards
Environment	Sustained Growth	Pattern of steady organizational growth
	High Risk Industry	Level of risk and stress in the business environment
	Industry Stability	Stability and predictability of the business environment

The DMPCs were measured on a 1–5 Likert scale through a survey. To enable FCA implication analysis, responses were binarized using the following rule. Values of 1–3 were coded as absence (0) of the characteristics, while values of 4–5 were coded as presence (1). This threshold reflected the distinction between the presence and absence of a decision-making characteristic and is consistent with FCA's focus on logical presence or absence rather than intensity.

3.3 Formal Concept Analysis

Formal Concept Analysis (FCA), introduced by Rudolf Wille (1982), is a mathematical framework used to analyze relationships between a set of objects and their attributes. FCA enables the identification of structured relationships within data by organizing objects based on shared attributes and deriving logical dependencies among those attributes. In this study, FCA is applied to examine how decision-making characteristics combine within owner organizations and to extract implication structures that describe consistent relationships among these characteristics.

The application of FCA in this research follows two primary steps: (1) the construction of formal contexts and (2) the extraction of implication sets. These steps transform the prepared dataset into a formal structure that allows for the systematic identification of conditional relationships among decision-making attributes.

3.3.1 *Formal Context Construction*

The first step in the FCA process is the construction of a formal context, which represents the relationship between a set of objects and a set of attributes. In this study, the objects correspond to owner organizations ($n = 109$), and the attributes correspond to the 22 binarized decision-making and project culture (DMPC) characteristics described in Section 3.2.1.

The formal context is represented as a binary incidence matrix, in which each row corresponds to an organization and each column corresponds to an attribute. A value of 1 indicates the presence of a characteristic within an organization, while a value of 0 indicates its absence. This binary structure defines the incidence relation between objects and attributes and serves as the foundation for all subsequent FCA operations.

To support the comparative objectives of this study, separate formal contexts are constructed for public and private owner organizations. By treating each subset as an independent context, the analysis captures context-specific relationships among attributes, allowing for a direct comparison of implication structures across ownership types.

3.3.2 *Implication Extraction*

Following the construction of formal contexts, FCA is used to derive implication relationships among attributes. An implication is a conditional statement of the form “if A, then B,” where A and B are sets of attributes. In this context, an implication indicates that whenever the attributes in A are present within an organization, the attributes in B are also present.

Implications are extracted using the Duquenne–Guigues basis, which provides a minimal and non-redundant set of implications that fully represents all valid attribute dependencies within a formal context. This basis ensures that the resulting implication set captures the complete logical structure of the data without duplication.

It is important to note that these implications are deterministic and context-dependent. They do not represent probabilistic associations or causal relationships; rather, they describe consistent co-occurrence patterns that hold across all observations within the dataset. As such, the implications reflect the internal structure of decision-making characteristics within each ownership context.

The extracted implication sets serve as the primary analytical output of this study. By comparing implication structures derived from public and private contexts, the analysis reveals how decision-making characteristics are configured within each group and identifies whether any relationships are shared across ownership types.

3.4 Software and Implementation

The Formal Concept Analysis (FCA) in this study was implemented using ConExp, a software tool specifically designed for constructing formal contexts, generating concept structures, and extracting implication sets. ConExp provides an integrated environment for performing FCA operations, including the derivation of the Duquenne–Guigues implication basis.

The analytical process followed a structured sequence. First, the prepared dataset was converted into a binary incidence matrix and imported into ConExp to construct the formal contexts. Separate contexts were created for the full dataset, as well as for public and private owner organizations, in accordance with the research design.

Within each context, ConExp was used to compute the concept structure and extract the corresponding implication sets. The Duquenne–Guigues basis was generated for each context, providing a minimal and non-redundant representation of all valid attribute dependencies. The resulting implication sets were then exported for further organization, filtering, and interpretation.

Chapter 4. Results

4.1 Overview of Results

Formal Concept Analysis (FCA), as introduced by Rudolf Wille and Ganter (2005), was applied to the public and private owner contexts to derive implication sets representing the relationships among decision-making characteristics. These implication sets constitute the primary analytical output of the study, capturing conditional relationships of the form “if A, then B” that hold universally within each context. The results provide a structured representation of how decision-making attributes combine within owner organizations and form the basis for comparative analysis across ownership types.

Three key findings emerge from the analysis. First, the implication structures derived from public and private contexts exhibit substantial divergence. The total number of implications differs between the two contexts, and only one implication is shared across both. This near-complete separation indicates that decision-making characteristics combine in fundamentally different ways across public and private owner organizations, suggesting that implication structures are strongly context-dependent.

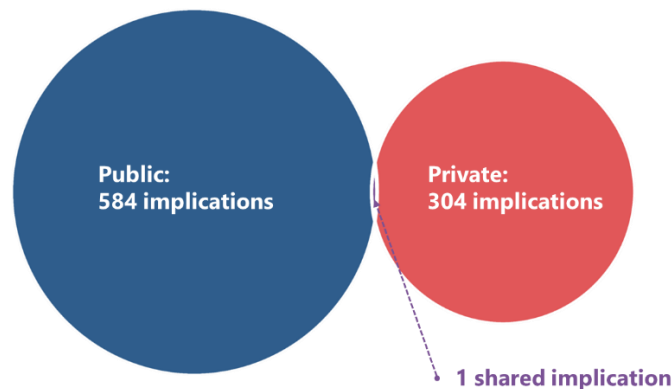


Figure 3 Results Overview

Second, despite this divergence, a single shared implication is identified across both contexts. This invariant implication results in a data-driven decision-making style and represents the only common structural relationship observed between public and private organizations. The presence of this shared implication suggests that data-driven behavior may function as a bridging mechanism across otherwise distinct decision-making environments.

Third, further analysis was conducted by examining implications in which the consequent corresponds to a data-driven decision-making style. This filtering approach enables a more detailed understanding of how data-driven behavior emerges within each context. The results indicate that while both public and private organizations exhibit data-driven decision-making, the configurations of characteristics that lead to this outcome differ between contexts. Public organizations tend to exhibit more consistent and repeated implications, whereas private organizations display greater variation in the combinations of attributes associated with data-driven behavior.

Together, these findings highlight three central insights: (1) strong structural divergence between public and private implication structures, (2) the presence of a single cross-sector invariant implication centered on data-driven decision-making, and (3) distinct pathways through which data-driven behavior emerges in each context. The following sections examine these findings in greater detail, beginning with the structural differences between public and private implication sets.

4.2 Structural divergence

The results reveal a clear structural divergence between the implication sets derived from public and private owner organizations. This divergence is evident both in the overall composition of the implication structures and in the relationships among decision-making characteristics within each context. By examining these differences, the analysis highlights how organizational attributes combine in distinct ways across ownership types, reflecting fundamentally different decision-making logics.

4.2.1 *Distinct Implication Structures*

The implication sets derived from the public and private contexts differ substantially in both size and composition. The public context yields a larger number of implications compared to the private context, indicating a denser network of attribute relationships. In contrast, the private context produces a smaller but more varied set of implications, suggesting a broader range of possible attribute combinations.

A key indicator of this divergence is the near-total lack of overlap between the two implication sets. Only one implication is shared across both contexts, while the remaining implications are unique to either public or private organizations. Given that implications represent relationships that hold universally within each context, this minimal overlap indicates that the underlying structures governing decision-making characteristics differ significantly between the two groups.

This divergence can be interpreted as reflecting the distinct institutional environments in which public and private organizations operate. Public organizations are typically subject to greater levels of formalization, accountability, and procedural constraint, which shape how decision-making characteristics are combined and expressed. In contrast, private organizations often operate with greater flexibility and fewer external constraints, allowing for more diverse configurations of decision-making attributes. These findings are consistent with prior research highlighting systematic differences between public and private sector decision-making practices (Nutt 2005; Rainey and Bozeman 2000; Meier and O'Toole 2011).

4.3 Cross-Sector Invariant Implication

Despite the substantial divergence between public and private implication structures, the analysis identifies a single implication that is shared across both contexts. This cross-sector invariant represents the only common conditional relationship observed in the study. As such, it offers important insight into how certain combinations of characteristics may produce consistent outcomes across different organizational environments.

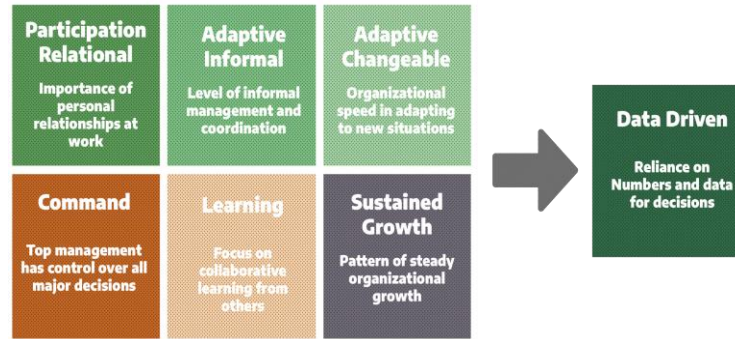


Figure 4 Cross Sector Implication; Left (A), Right (B)

4.3.1 Interpretation of Shared Implication

The shared implication takes the form of a conditional relationship in which a specific configuration of decision-making characteristics leads to a data-driven decision-making style. The antecedent of this implication includes attributes associated with participatory and relational decision-making, adaptive and informal processes, and a combination of cultural orientations that reflect both command-driven and learning-based approaches. Additionally, the configuration is associated with environments characterized by sustained growth.

Taken together, this combination of attributes reflects a hybrid organizational configuration in which elements of flexibility and structure coexist. The presence of both participatory and authoritative characteristics suggests a balance between inclusion and control, while the combination of adaptive processes and learning-oriented culture indicates an openness to change alongside the need for coordination. This hybrid structure appears to create conditions under which data-driven decision-making consistently emerges.

This interpretation aligns with prior research on strategic decision-making, which highlights the importance of combining analytical and relational processes in complex organizational environments (Papadakis et al. 1998; Elbanna 2006). Rather than relying on a single dominant decision-making mode, organizations often integrate multiple approaches to navigate competing demands and uncertainties.

4.3.2 *Meaning of Data-Driven Style as a Result*

Within this shared implication, the data-driven decision-making style emerges as the consequent, indicating that it is consistently associated with the identified configuration of attributes. Importantly, this finding suggests that data-driven behavior is not an isolated characteristic but rather the result of specific combinations of organizational conditions. In both public and private contexts, the presence of participatory, adaptive, and hybrid cultural attributes appears to support the adoption of data-driven approaches to decision-making.

One possible interpretation is that data functions as a coordinating mechanism within complex organizational environments. In contexts where multiple decision-making logics coexist—such as participation and authority, or flexibility and structure—data may provide a common reference point that facilitates alignment and supports justification of decisions. This is particularly relevant in settings characterized by growth and change, where uncertainty and competing priorities require mechanisms for consistency and transparency.

The fact that this implication is shared across both public and private contexts further underscores its significance. While the broader implication structures differ substantially between sectors, this invariant relationship suggests that data-driven decision-making may play a similar role in both environments when certain conditions are present. Rather than being tied to a specific organizational type, data-driven behavior appears to emerge from a particular configuration of decision-making characteristics that transcends sector boundaries.

4.4 *Implications with Data-Driven Style as a Result*

To further examine the role of data-driven decision-making within owner organizations, the analysis focuses on implications in which the consequent corresponds to a data-driven decision-making style. By filtering the implication sets in this way, the study isolates the implications that consistently lead to data-driven behavior within each ownership context. This approach enables a more detailed comparison of how data-driven decision-making emerges across public and private organizations.

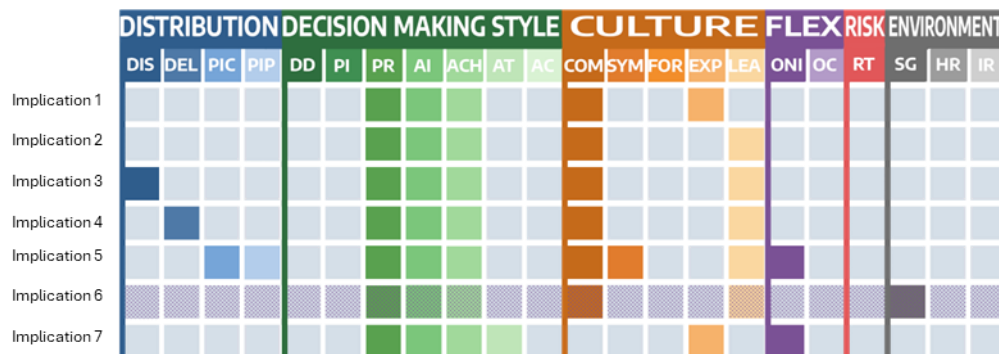
4.4.1 Public sector and Data-Driven Style

In the public context, implications leading to a data-driven decision-making style exhibit a high degree of consistency in their antecedent configurations. Similar combinations of attributes appear repeatedly across multiple implications, indicating that data-driven behavior is associated with a relatively stable set of organizational conditions. These recurring attributes often include elements of formal structure, participation, and defined processes, suggesting that data-driven decision-making in public organizations is embedded within structured and predictable configurations.

This pattern reflects the influence of formal governance mechanisms and accountability requirements commonly associated with public organizations. The consistency of antecedent configurations suggests that data-driven approaches are not adopted in isolation but are integrated within established decision-making frameworks. As a result, the pathway to data-driven behavior in public contexts appears to be relatively constrained, relying on specific combinations of characteristics that recur across organizations.

4.4.2 Private Sector and Data-Driven Style

Figure 5 Implications with Data Driven as a result (B) in the Public Owner Context



In contrast, the private context displays greater variation in the antecedent configurations associated with data-driven decision-making. The implications show a wider range of attribute combinations, with fewer recurring patterns across the dataset. This diversity indicates that data-driven behavior in private organizations can emerge through multiple pathways, rather than being tied to a single or consistent configuration.

The variability observed in the private context suggests a more flexible and adaptive approach to decision-making. Organizations appear to combine different characteristics depending on their specific conditions, allowing data-driven practices to be integrated in a variety of ways. This flexibility may reflect fewer formal constraints and greater discretion in how decision-making processes are structured, enabling organizations to tailor their use of data to their operational context.

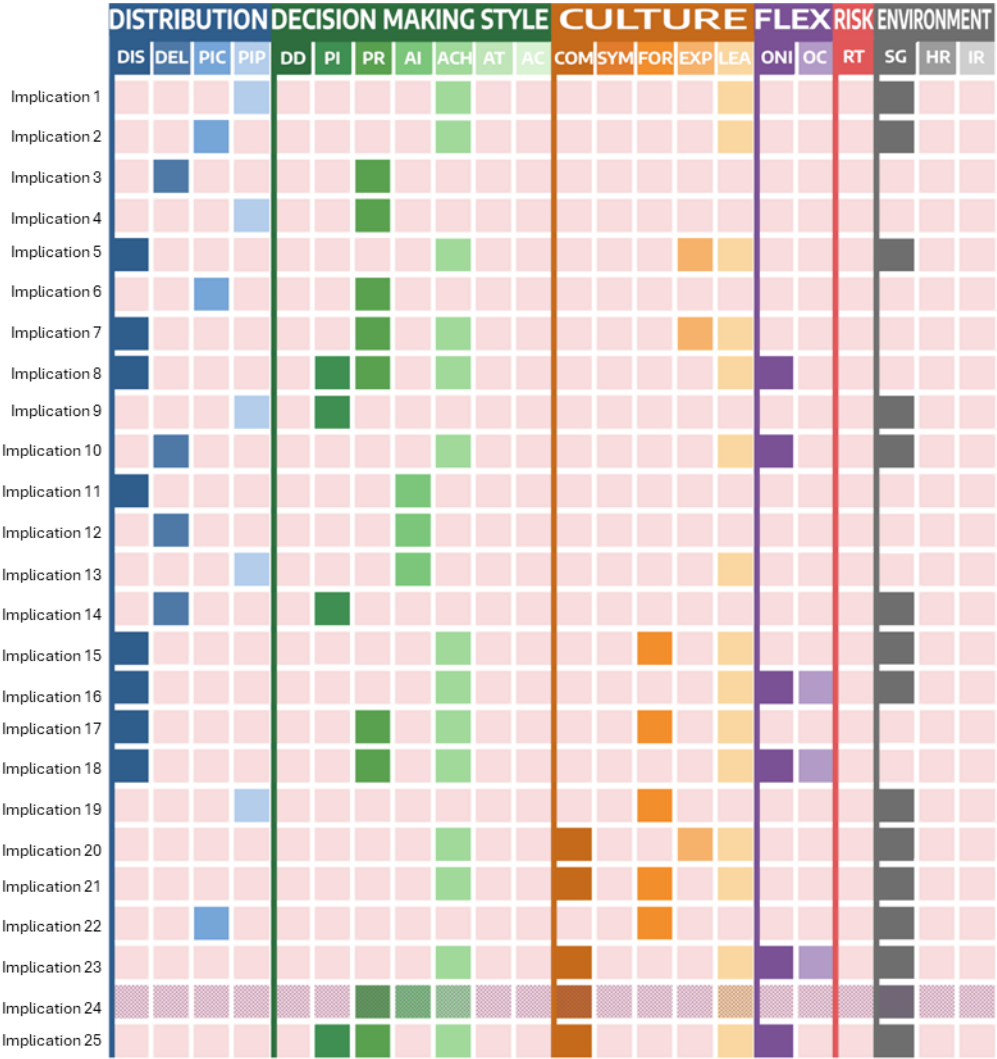


Figure 6 Implications with Data Driven as a result (B) in Private Owner Context

4.4.3 Comparison between Public and Private

Certain characteristics—particularly Sustained Growth Environment and Command culture —exhibit uneven patterns of occurrence across the two contexts, revealing differences in their structural role within

decision-making configurations. In one context, these attributes appear only in a limited number of implications, indicating a more peripheral role in shaping decision-making outcomes. In the other context, however, they recur across multiple implication rules, often in combination with attributes such as Participation Relational style, Adaptive Informal Style, and Learning Culture. This recurrence suggests that sustained growth and command-oriented culture are more structurally embedded, contributing consistently to the formation of configurations that lead to specific outcomes. From an FCA perspective, this distinction reflects not only differences in frequency but also in the configurational prominence and stability of these attributes within each context's implication structure.

Despite these structural differences, both contexts demonstrate that data-driven decision-making style is not an isolated attribute but the result of specific configurations of interdependent characteristics. Across both sectors, data-driven behavior emerges only when particular combinations of attributes are present, reinforcing the idea that decision-making outcomes are configurational rather than individual. However, the nature of these configurations differs: in one context, data-driven decision-making is associated with a more consistent set of antecedent attributes, suggesting stable and predictable pathways, whereas in the other, it arises from a broader and more varied set of configurations, indicating flexible and adaptive pathways.

This distinction highlights that the key difference between sectors lies not in whether organizations adopt data-driven approaches, but in how these approaches are structurally produced and embedded within their decision-making systems. Overall, these findings reinforce the conclusion that decision-making configurations are context-dependent, while also demonstrating that similar outcomes can emerge through fundamentally different structural pathways, depending on how organizational characteristics interact within each context.

Chapter 5. Conclusion

Owner organizations play a central role in shaping decision-making in building construction, yet prior research has primarily examined decision-making characteristics as isolated traits rather than as structured combinations that operate within specific organizational contexts. To address this gap, this study applied FCA to decision-making profile data from the BOAT in order to examine how DMPCs combine into formal implication structures. By creating separate formal contexts for public and private owner organizations and deriving Duquenne–Guigues implication bases for each, the study adopted a logic-based, configurational approach to compare the decision-making configuration across ownership types.

The study discovered three critical findings. First, Public and private owners exhibited different, non-overlapping implication sets, indicating a strong structural divergence in how decision-making attributes co-occur within each ownership context. Second, despite this broad divergence, one formal implication was shared across public and private contexts, linking a specific combination of relational, adaptive, informal, and changeable styles, cultural and learning cultures, and sustained growth environmental DMPCs to a data-driven decision-making style. Third, analysis of implications with data-driven decision-making as the consequent revealed differing structural patterns across contexts: in one context, configurations were relatively consistent and clustered around similar sets of antecedent characteristics, while in the other, configurations were more varied, suggesting multiple pathways leading to data-driven outcomes. Together, these findings indicate that while decision-making structures are largely context-dependent, similar outcomes may emerge through fundamentally different configurations of characteristics.

This study contributes to the construction management literature in two important ways. First, it addresses a critical gap by moving beyond variable-oriented analyses of owner decision-making and revealing how decision-making characteristics, in this study defined as DMPCs, combine into distinct implications within public and private owner contexts. In doing so, the study demonstrates that differences between public and private owners are not limited to individual decision-making characteristics or institutional conditions but are reflected in fundamentally different implications among both sectors. Second, the study demonstrates the value of logic-based configurational methods, such as FCA, and shows how they can advance

understanding of owner decision-making in construction, providing a methodological foundation for future research.

Despite the contribution, this study should consider the following limitations. First, the analysis focused on ownership type and did not examine other organizational dimensions from the BOAT study, such as organizational size, geographic dispersion, or departmental structure. Second, the binarization of Likert scale survey responses may obscure nuanced decision-making patterns that FCA cannot uncover.

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