Smart Design Policies

*2025, Volume 2, Number 1, pages 179–195*

*Original scientific paper*

# Evolving Power Structures in Megaproject Governance: A Temporal SNA and Powercube Analysis of the BSCU Project

* **Huda Almadhoob**

Department of Architecture and Interior Design, Faculty of Engineering, University of Bahrain, Bahrain

E-mail: halmadhoob@uob.edu.bh

**ORCID**: https://orcid.org/0000-0001-9836-6008

**ARTICLE INFO:**

**Article History:**
Received: 23 July 2025
Revised: 15 October 2025
Accepted: 02 November 2025
Available online: 05 November 2025

**Keywords:**
Adaptive governance; project governance; social network analysis; infrastructure projects; megaprojects; governance dynamics.

**ABSTRACT**

*Megaprojects are crucial for developing urban systems, yet their governance is often characterised by disputed authority, shifting coalitions, and uneven stakeholder influence. This paper examines the evolution of power structures in megaproject governance through an integrated methodological approach, that combines temporal social network analysis with the PowerCube framework. Using the Bank Station Capacity Upgrade project in London as a case study, the research traces how visible, hidden, and invisible forms of power interacted across two stages of the project, identifying turning points where stakeholder centrality and influence shifted. This study contributes new knowledge to urban management and governance in three ways. First, it demonstrates that power in large infrastructure projects is not fixed but changes over time as new actors join, coalitions change, and governance spaces are reconfigured. Second, it introduces a novel way of studying these changes by combining social network analysis, which maps relationships between actors, with the PowerCube framework, which highlights visible, hidden, and invisible forms of power. Third, the paper provides original evidence from the Bank Station Capacity Upgrade project, demonstrating how governance mechanisms shaped decision-making and stakeholder legitimacy in one of London's most complex transport systems. By connecting megaproject governance to urban management concerns, the paper offers both scholarly insights and practical recommendations for policymakers and practitioners seeking to enhance transparency, adaptability, and stakeholder engagement in complex infrastructure delivery.*



SMART DESIGN POLICIES (2025), *2*(1), 179–195.
https://doi.org/10.38027/smart.v2n1-12

www.smartdpj.com



**How to cite this article:** (APA Style)
Almadhoob, H. (2025). *Evolving power structures in megaproject governance: A temporal SNA and Powercube analysis of the BSCU project*. *Smart Design Policies*, *2*(1), 179–195. https://doi.org/10.25034/smart-v2n1-12

## 1. Introduction

### 1.1 Background and Context

Urban infrastructure megaprojects play a central role in shaping the growth, mobility, and functioning of cities, yet they are also frequently associated with cost overruns, delays, and governance failures (Flyvbjerg & Gardner, 2023). Governing such projects is particularly challenging due to their inherent complexity, dynamic stakeholder environments, and evolving power relations (Brunet, 2019; Aaltonen & Sivonen, 2009).

As projects unfold, formal governance mechanisms, such as contracts, hierarchies, reporting structures, interact with informal networks of influence, shaping decision-making, coordination, and project outcomes (Gil et al., 2017; Winch, 2014; Loosemore, 1998; Pitsis et al., 2003). Yet, despite the inherently temporal nature of these dynamics, most governance frameworks fail to account for how power relations develop and shift across the lifecycle of a project.

Therefore, understanding how these power structures evolve over time is critical to improving project governance and is highly relevant to broader debates in urban management, where legitimacy, adaptability, and decision-making processes underpin the success of complex infrastructure delivery. However, many existing analytical approaches remain static, offering only snapshots of networks at particular stages. This temporal blindness limits their explanatory potential, as governance is not only relational but also continuously renegotiated across the different project phases.

### 1.2 Research Gap and Objectives

Relational perspectives on project governance have gained traction, yet much of the literature focuses on mapping networks or identifying key actors at a single stage (Almadhoob, 2020). Such approaches fail to consider how roles and influence evolve over time, thereby neglecting the dynamic nature of power shifts. Infrastructure projects, such as the Bank Station Capacity Upgrade (BSCU), demonstrate that governance structures are dynamic: the influence of different actors changes, new stakeholders become involved, and governance spaces adjust in response to internal dynamics and external pressures (Brady & Davies, 2013). Consequently, static analyses risk obscuring these changes, limiting understanding of how governance evolves.

The PowerCube framework (Gaventa, 2006) offers a multidimensional lens to examine how power operates across different levels, spaces, and forms, yet its applications often remain episodic and lack temporal perspective (Pantazidou, 2012; Gaventa, 2019). Similarly, Social Network Analysis (SNA) offers relational mapping but is also typically constrained to single points in time (McCulloh & Carley, 2009; Ferreira et al., 2015). This creates a gap in literature where few studies capture how power relations and governance evolve dynamically across the lifecycle of megaprojects, despite their centrality to urban governance and management.

This paper addresses this gap by integrating temporal SNA with the PowerCube framework. This approach reveals how power accrues, dissipates, and restructures across project stages—insights that static methods cannot capture. Using longitudinal network data from two stages of the BSCU project, we trace how governance structures and power relations evolved as the project shifted from functionally driven governance to delivery-driven, multi-disciplinary governance.

The study builds on and extends prior doctoral research (Almadhoob, 2020), which explored complexity in megaproject networks. What this paper adds is a temporal lens—showing not just where power resides, but how it shifts across the project lifecycle, and with what implications for governance effectiveness and urban management. Specifically, the study asks three questions:

Q1: How do power relations among project actors evolve over time?
Q2: What are the governance implications of these shifts?
Q3: How can project governance strategies be adapted in response to evolving power structures?

### 1.3 Contribution and Structure of the Paper

This paper makes three key contributions. Theoretically, it advances understanding of project governance by conceptualising it as a dynamic and relational process rather than a fixed arrangement, thereby extending debates on adaptive governance in the context of urban infrastructure. Methodologically, it demonstrates the value of integrating temporal network analysis with the PowerCube framework, which together allow researchers to capture not only how actors are positioned in networks but also how different forms of power shift and are reconfigured over the course of a project. Empirically, it draws on the BSCU project in London to provide detailed evidence of how governance mechanisms shaped stakeholder legitimacy and decision-making within a highly complex urban environment. These findings offer both scholarly insights into the evolving nature of megaproject governance and practical lessons for managing large-scale infrastructure projects worldwide.

The remainder of the paper is structured as follows. Section 2 reviews relevant literature on project governance, power, and network analysis. Section 3 outlines the methodology, including the integration of SNA and PowerCube. Section 4 presents the findings from the BSCU case. Section 5 discusses the conclusions and implications for governance theory and practice, with contributions and future research directions.

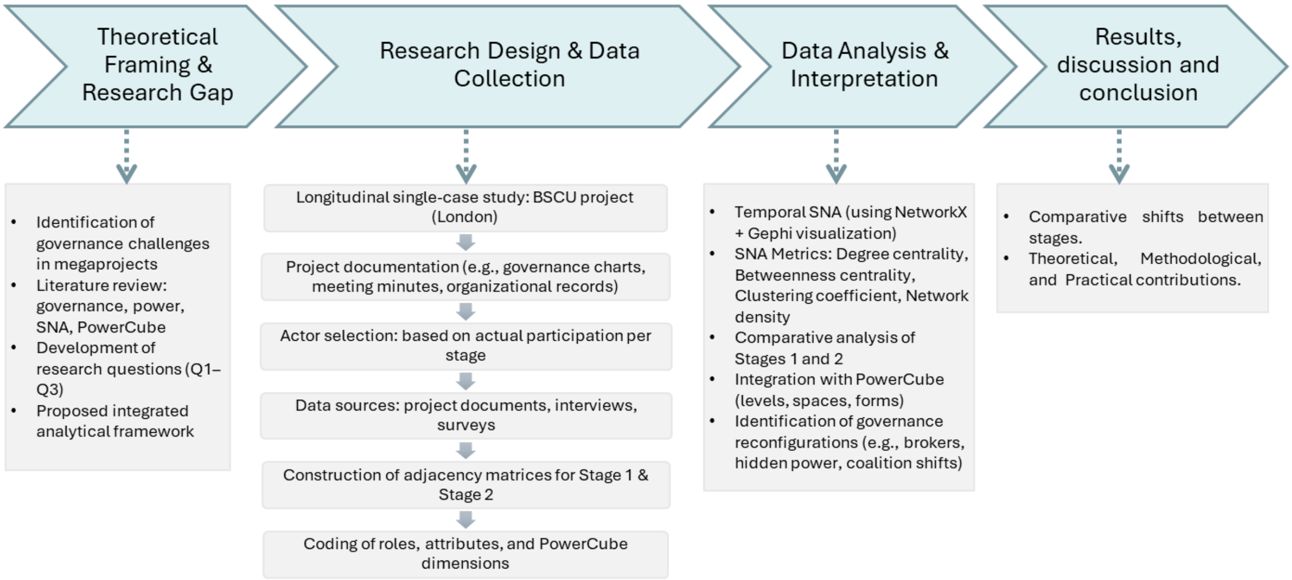


**Figure 1.** Research Framework.

## 2. Literature Review

### 2.1 Governance and Power in Construction Projects

Project governance refers to the frameworks, processes, and relational mechanisms through which large, complex projects are directed, coordinated, and controlled (Müller, 2016). In construction and infrastructure contexts, governance must address the inherent uncertainty, risk, and multi-stakeholder complexity of delivering major capital projects (Brady & Davies, 2013; Winch, 2014). These challenges are particularly amplified in large-scale, urban megaprojects, which often span organizational, sectoral, and institutional boundaries.

Scholars increasingly argue that project governance cannot be perceived only as a hierarchical form but as an emergent multilinear process — including formal and informal institutions, relations, and negotiations (Addyman & Smyth, 2023; Pryke, 2005; Brunet, 2019; Gil et al., 2017). In this sense, governance is relational and networked, not just contractual or structural. Recent research emphasizes that this relational nature is not a peripheral characteristic but is crucial to how megaprojects are coordinated and delivered (Richard, 2025; Xu et al., 2025; Addyman & Smyth, 2022).

The latter is particularly relevant to large-scale urban infrastructure projects, including the BSCU project, as they involve a wide range of stakeholders and span multiple organizational, sectoral, and institutional boundaries. In such projects, governance is continually challenged by shifting power dynamics among stakeholders, necessitating adaptive and reflexive management approaches (Pitsis et al., 2003; Brouwer et al., 2023).

Therefore, power is central to governance; it shapes whose voices are heard, whose interests prevail, and how decisions are made and implemented (Clegg, 1989; Ling et al., 2014). In complex project environments, power is not simply vested in formal authority structures; it functions through relationships, by networks of influence, trust, and flow of information (Pryke, 2005). This includes symbolic and knowledge-based power, such as control over project narratives, technical legitimacy, information sharing, and access to institutional channels (Pettit, 2013; Wang et al., 2025).

Recent studies in project management have begun to explore how relational power manifests in project networks (Chinowsky et al., 2010; Aaltonen & Sivonen, 2009). Nevertheless, a large portion of this work is still descriptive, mapping network structures without systematically linking them to governance outcomes. Moreover, power in project governance is dynamic, with actors gaining and losing influence as projects progress, yet only a limited number of studies have empirically examined these changes over time.

Additionally, research on infrastructure development in various regions (e.g., Southeast Asia and Sub-Saharan Africa) further demonstrates that governance trajectories are deeply shaped by context-specific institutional arrangements and historic power imbalances, which determine how informal influences shape formal decision-making (Souza, 2025; Hakim et al., 2025). This emphasizes the need to move beyond snapshot analyses toward tools and frameworks that can trace evolving governance dynamics across time and space.

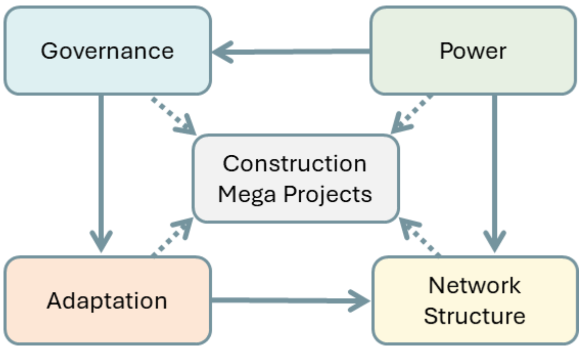


**Figure 2.** Conceptual Framework.

### 2.2 Adaptive Governance Theory

This paper builds on these bodies of work to propose a dynamic framework for analyzing project governance, integrating Social Network Analysis (SNA) and PowerCube in a temporal perspective. By applying SNA to track changes in network structure and actor centrality across project stages, and combining this with PowerCube coding of actors' roles and spaces, we aim to illuminate how governance spaces and power structures evolve as projects progress. This integrated approach addresses two key gaps:

(1) It brings a dynamic lens to project governance, capturing how shifts in network power influence governance processes over time.

(2) It operationalizes PowerCube within a network analysis framework, enabling systematic analysis of how visible, hidden, and invisible power manifest and shift in relational project contexts.

Recent studies on adaptive governance in infrastructure megaprojects emphasize the importance of integrating contractual mechanisms (like Early Contractor Involvement (ECI) and relational contracting), collaborative governance structures, and learning loops to manage emergent complexities, uncertainties, and stakeholder dynamics (Hartmann & Bresnen, 2011; Gil et al., 2018; Brunet, 2019; Xue & Xue, 2025; Nwajei, 2021). Mechanisms such as NEC Target Cost contracts and gain-pain share schemes incentivize collaboration and adaptability, while integrated governance boards, multi-level participation, and feedback loops build trust and promote cross-functional learning (Pitsis et al., 2003; Winch, 2014; Xue & Xue, 2025; Brunet & Choinière, 2025).

This adaptive interpretation responds directly to the governance challenges identified in megaproject literature, where rigid, top-down structures often fail under conditions of uncertainty and change (Flyvbjerg & Gardner, 2023; Van Assche et al., 2022). As projects move from the planning stage to delivery and implementation, governance must evolve accordingly, requiring flexible systems that

can absorb changes in project teams, negotiate new roles, formalize new routines, and adapt to emergent risks.
However, understanding how these adaptive mechanisms operate in practice requires complementary analytical tools. Recent studies stress that adaptive governance alone is not sufficient if the evolving dynamics of authority, legitimacy, and stakeholder influence are not also tracked (Wu & Yao, 2025; Lok et al., 2025). This is particularly crucial in projects where technical rationality often dominates stakeholder deliberation, leading to hidden asymmetries in decision-making.
Combining PowerCube and Temporal SNA offers a novel approach to visualize how governance spaces, levels, and forms of power change through different project stages, offering deeper understanding of how adaptive governance operates in complex, multi-actor project environments. This integrated lens reveals not only how governance adapts structurally, but how relational and informal forms of power evolve and shape project decisions and results over time.

### 2.3 Integrating SNA and the PowerCube Framework

Building on the preceding discussion, this study adopts a combined methodological framework that integrates SNA with the PowerCube (Gaventa, 2006). This integration provides a relational and temporal lens for examining how power is exercised and reconfigured in large infrastructure projects. The PowerCube (Figure 3) offers a structured model for analyzing power across three interconnected dimensions:

- **Levels:** decision-making across local, organizational/meso, and systemic/global arenas;
- **Spaces:** the arenas in which governance is enacted, ranging from closed spaces (exclusive decision-making) to invited spaces (participation through structured channels), and claimed/created spaces (emergent or autonomous arenas);
- **Forms:** visible (formal, institutionalised authority), hidden (backstage influence and agenda setting), and invisible (cultural norms, discursive control).

In project governance contexts, this framework provides a powerful means of unpacking not just formal structures of authority (e.g. visible power in invited spaces), but also informal, relational, and discursive dynamics that shape project outcomes. It is particularly useful in identifying how governance is practiced beyond contractual hierarchies — through influence, framing, and networked control.
Although the PowerCube has been applied in participatory governance and development settings (Brock et al., 2001), its application to complex infrastructure projects remains underutilized. Moreover, existing applications tend to be static, offering only snapshots of power rather than accounting for its evolution over time — a significant limitation in contexts where stakeholders, alliances, and governance structures are constantly in flux.
On the other hand, SNA complements PowerCube by providing quantitative tools to explore how power circulates through relationships, mapping the flow of information, resources, and influence across project actors. SNA has been widely used in project contexts to investigate:

- Stakeholder relationships (Lin et al., 2024; Yang et al., 2009);
- Knowledge sharing (Leon et al., 2024; Senaratne et al., 2021; Park & Lee, 2014);
- Collaboration and coordination patterns (Ali & Haapasalo, 2024; Loosemore, 1998);
- Risk communication networks (Lu et al., 2024; Xie et al., 2019).

SNA operationalizes the “*who connects to whom*” dimension of power and provides metrics which are explained below in methodology section.
However, most SNA studies in project research have remained temporally flat, rarely capturing how relationships, roles, and power structures evolve over different phases of the project lifecycle. This is a critical oversight in projects where governance is shaped by dynamic processes, shifting responsibilities, and emergent collaborations.

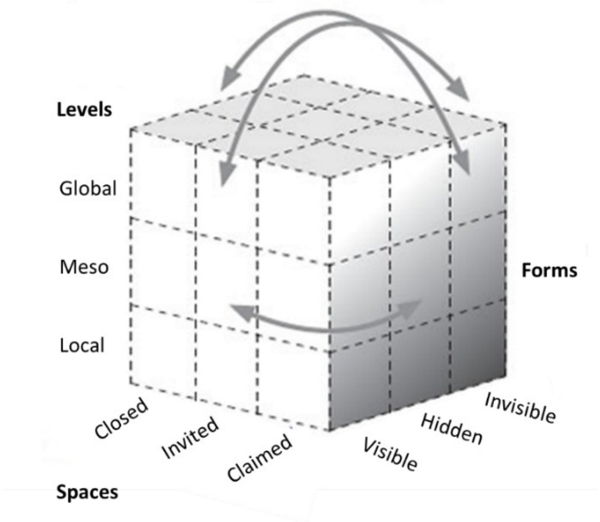


**Figure 3.** PowerCube Framework (Source: Gaventa, 2006).

## 3. Materials and Methods

### 3.1 Research Design and Case Context

This study adopts a longitudinal single-case study design (Yin, 2009), focusing on the evolving governance dynamics of the Bank Station Capacity Upgrade (BSCU) project in London. The BSCU project is a major urban infrastructure initiative aimed at improving capacity, reducing congestion, and enhancing passenger flows at one of London's busiest underground stations. Its extended timeline, phased delivery, and complex decision-making processes provide analytical richness, that enable observation of how governance arrangements and stakeholder power relations shifted over time. This directly addresses Q1 of the research, which seeks to understand how power relations among project actors evolve over time.

The project's inherent complexity further strengthens its relevance as a case study. Located in a highly constrained underground setting with live railway operations and significant technical challenges, it required coordination across a diverse set of stakeholders, including Transport for London, London Underground Ltd, Dragados as the main contractor, design consultants such as AECOM, regulatory bodies, and local community groups. This combination of spatial constraints, technical difficulties, and inter-organizational diversity creates a rich environment for analysing how governance structures and stakeholder power evolve in large-scale infrastructure projects (Brunet, 2019, p. 19).

In response to this complexity, the BSCU project adopted explicit adaptive governance mechanisms, including an Early Contractor Involvement (ECI) phase to support iterative planning and joint risk mitigation; relational contract structures aligned with NEC4 Target Cost/Gain-Pain Share models, and multi-level governance arrangements such as joint TfL–Dragados governance boards, Integrated Project Teams (IPTs), and collaborative planning workshops. These mechanisms intentionally created a working environment that fosters learning loops, enabling continuous feedback to be shared easily between site teams, design groups, and governance boards. Examining these arrangements allows the paper to address Q3, which inquire about how governance strategies can be adapted in response to evolving power dynamics.

To capture how governance evolved through this dynamic, multi-actor environment, the study adopted the integrated methodology explained. Specifically, the research focuses on the analysis of actor networks at two project stages, enabling the tracking of changes in power structures, governance spaces, and functional roles (Pitsis et al., 2003; Gaventa, 2006; Xue & Xue, 2025). This integrated approach addresses both Q1, by tracing how actor influence shifts over time, and Q2, by examining the governance implications of these shifts through the lens of levels, spaces, and forms of power.

Although rooted in London, the observed mechanisms highlight challenges typical to megaprojects globally, providing insights transferable insights into governance and power dynamics in complex urban infrastructure projects.

### 3.2 Data Collection and Analytical Approach

The data for this study were drawn from the author's earlier doctoral research (Almadhoob, 2020), supplemented with additional actor attribute data collected specifically for this analysis. Primary data sources included project documentation, interviews with key stakeholders, and the development of adjacency matrices capturing actor relationships at the two chosen project stages. These sources directly support Q1 by enabling analysis of how relationships and influence evolved over time.

- **Actor Selection:** Actors included in the analysis were those directly participating in the project at each stage examined. In Stage 1, this consisted of the initial project team handling design coordination and governance setup, whereas Stage 2 included a larger group reflecting the expanded involvement of delivery functions. In other words, actor selection was not based on sampling criteria but on actual project participation at the given stage, ensuring that the constructed networks accurately represented the governance environment as it evolved. Additionally, Project documentation (e.g., governance charts, meeting minutes, organizational records) was used to identify actors, validated through interviews and survey responses to confirm active participation. This selection approach ensures that findings remain aligned with Q1 and Q2, by reflecting the full set of actors involved in shifting power and governance arrangements.
- **Adjacency Matrices and Temporal Stages:** Two directed, weighted adjacency matrices were constructed to represent the network at each stage. Each adjacency matrix captured the presence and strength of ties/relationships between actors, based on communication frequency, collaboration intensity, and influence patterns, as reported in survey responses and validated against project records and interview insights. The matrices were structured to enable directed graph analysis suitable for SNA.
- **Actor Coding and Reliability:** Functional roles (e.g., Civils, Design Management, Systems Engineering) and managerial attributes were coded. This enabled interpretation of SNA results in terms of evolving governance patterns and cross-functional collaboration.
  Coding reliability was addressed through an iterative process. First, attribute categories were developed using established frameworks (Brock et al., 2001; Gaventa, 2006; Aaltonen & Sivonen, 2009), then applied to the dataset. Consequently, the initial coding was cross validated through triangulation with interview data and project records. It is worth mentioning that although coding was primarily conducted by the author, two independent colleagues reviewed a subset of classifications to minimize subjectivity and enhance reliability. This coding was necessary to interpret the governance implications of evolving roles, directly linking to Q2.
- **Relevance of PowerCube Dimensions to Megaprojects:** The PowerCube dimensions are particularly salient in megaproject contexts because they reflect the multi-level, multi-space, and multi-form nature of power in such settings. Governance spans multiple levels, from site-based teams to corporate boards and regulators. Power is exercised across diverse spaces: formal contractual boards (invited spaces), restricted technical reviews (closed spaces), and emergent informal arenas (claimed spaces). Forms of power extend beyond formal authority (visible) to relational influence (hidden) and discursive or cultural dynamics (invisible). This multidimensionality makes PowerCube especially suited to large projects like BSCU, where governance is characterized by evolving coalitions and contested arenas of negotiation. This operationalisation enables analysis of the governance implications of shifting power (Q2) and provides a basis for evaluating adaptive strategies (Q3).

### 3.3 Network Analysis and Interpretation

Temporal SNA was conducted using NetworkX (Python), with visualizations generated in Gephi Software. For each stage, the following metrics were calculated (Borgatti, 2005):

- **Degree centrality:** refers to the number of direct connections an actor has within a network. It is an indication of actor visibility and network reach (i.e. (actors with high visibility in governance networks);
- **Betweenness centrality:** assesses the extent to which a node/actor lies on the shortest paths between other nodes/actors. It is an indication of brokerage and control over information flows (i.e. brokers controlling access and flows across silos);
- **Clustering coefficient:** it measures the degree to which nodes/actors in a network cluster together. Therefore, it gives indication on local network cohesion and potential invisible power clusters;
- **Network density:** reflects the proportion of actual connections to possible connections in the network. Therefore, it reflects overall network interconnectedness (i.e. overall interconnectedness of the governance system).

In response to Q1 and Q2 of this research, SNA analysis tracked changes in these metrics at both the individual actor level and the aggregate network level, identifying:

- Actors whose influence increased or decreased over time;
- New entrants and actors whose roles declined;
- Shifts in brokerage roles and governance spaces.

Results were then interpreted through the PowerCube dimensions of levels, spaces, and forms. This mapping directly addresses Q2, by connecting relational network metrics to the governance implications of visible, hidden, and invisible power. As summarised in Table 1, degree centrality aligns with visible power in invited spaces, betweenness centrality with hidden brokerage and gatekeeping, clustering coefficients with invisible power in claimed spaces, and network density with the expansion of invited and participatory governance. The addition of temporal dynamics allows these dimensions to be traced longitudinally, showing how visible power in closed spaces can shift toward hidden or invisible influence in more open, invited arenas. This provides insights for Q3, by identifying governance mechanisms that enable adaptation in response to shifting power relations.

This integrated interpretation enables governance analysis that goes beyond descriptive network mapping, uncovering how power is exercised, contested, and reconfigured across project stages. In turn, it provides actionable insights into how evolving relational dynamics shape and challenge governance in large infrastructure projects.

**Table 1:** Operationalizing SNA Metrics into PowerCube Dimensions.

| SNA Metric | Operational Meaning in Networks | Mapped PowerCube Dimension | Interpretation in Project Governance |
|---|---|---|---|
| **Degree Centrality** | Number of direct ties an actor holds (visibility and reach in the network) | Forms → Visible Power | Indicates formally recognised influence in invited spaces. |
| **Betweenness Centrality** | Extent to which an actor lies on shortest paths between others (brokerage/control) | Forms → Hidden Power / Spaces → Gatekeeping | Identifies hidden brokers who control access to spaces and information. |
| **Clustering Coefficient** | Measures local cohesion (tendency of nodes to form tight groups) | Forms → Invisible Power / Spaces → Claimed | Sub-networks represent created/claimed spaces where norms and discourses shape legitimacy. |
| **Network Density** | Ratio of actual to possible ties (overall connectedness of network) | Spaces → Expansion of Invited Spaces / Levels | Reflects shift toward more participatory, polycentric governance. |
| **Temporal Dynamics** | Changes in metrics across project stages | Interaction of Levels, Spaces, and Forms | Captures how power evolves: from visible power in closed spaces to hidden/invisible power in invited spaces. |

## 4. Results and Discussion

### 4.1 Network Evolution Across Project Stages

The global network analysis (Table 2) shows that the BSCU project network expanded and became more interconnected between Stage 1 and Stage 2. The number of actors increased from 162 to 197, and ties grew from 1,440 to 2,207. Density and clustering also increased slightly, indicating stronger collaboration and the emergence of local clusters. From an adaptive governance perspective, this represents a move away from segmented, functionally bounded governance toward a more polycentric structure with greater feedback capacity among the different network clusters (Brunet, 2019; Pitsis et al., 2003; Van Assche et al., 2022). This directly addresses Q1 by showing how actor relationships expanded and became more interconnected over time, reflecting the temporal evolution of power relations within the project. It also aligns with the study's central aim of demonstrating that governance in megaprojects is not static but evolves dynamically, a point that could not be fully captured through static approaches.

**Table 2:** Network metrics comparison (stage 1 vs. stage 2 global network metrics. Source: Original).

| Metric | Stage 1 | Stage 2 |
|---|---|---|
| **Number of Nodes (no. people)** | 162 | 197 |
| **Number of Edges (no. relationships)** | 1,440 | 2,207 |
| **Network Density** | 0.055 | 0.057 |
| **Average Clustering Coefficient** | 0.384 | 0.416 |

### 4.2 Stage 1: Functionally Driven Governance

As shown in Table 3, Stage 1 governance was dominated by Civils & Structures, which ranked highest in both degree and betweenness centrality. This reflects a governance mode centered on technical expertise, where decision-making authority was concentrated within discipline-specific hierarchies (contracts, reporting lines). Project Controls and Project Management provided a secondary tier of coordination authority, facilitating risk reporting and schedule alignment.

Interestingly, smaller functions such as Risk Management, Health & Safety, and Quality exhibited disproportionately high betweenness centrality relative to their size, suggesting that they acted as hidden brokers across technical silos. This reflects the operation of hidden forms of power (Gaventa, 2006), where authority flows through informal brokerage rather than formal hierarchy. From an adaptive governance lens, these hidden brokers contributed resilience by embedding safeguards into early-stage governance (Folke et al., 2005; Nwajei, 2021).

Peripheral functions such as Systems Engineering, Architectural Design, and Operations remained marginal, indicating that whole-life and integrative considerations had not yet entered the governance mainstream. Overall, Stage 1 governance aligned with a closed, functionally segmented model, with decision-making authority anchored in visible technical power.

These findings further illustrate Q1, highlighting how early-stage governance was dominated by a few technical hubs with limited cross-functional integration, and set the baseline for assessing governance implications (Q2) as the project progressed. At this stage, the integrated methodology proved functional, in the sense SNA revealed central hubs and hidden brokers, while PowerCube provided the interpretive lens to understand how visible and hidden power operated within closed governance spaces. Figure 4a visually confirms this concentration around the technical hubs.

**Table 3:** Stage 1 functional governance summary (ranked by average degree centrality).

| Rank | Function / Role | Number of Actors | Avg. Degree Centrality | Avg. Betweenness Centrality |
|---|---|---|---|---|
| 1 | **Civils & Structures** | 13 | 0.302 | 0.053 |
| 2 | **Project Controls & Project Management** | 9 | 0.251 | 0.047 |
| 3 | **Tunnelling Design** | 14 | 0.223 | 0.040 |
| 4 | **Risk Management** | 2 | 0.200 | 0.075 |
| 5 | **Health & Safety** | 2 | 0.187 | 0.062 |
| 6 | **Systems Engineering** | 5 | 0.145 | 0.032 |
| 7 | **Architectural Design** | 6 | 0.132 | 0.018 |
| 8 | **Quality** | 2 | 0.128 | 0.059 |
| 9 | **Project Support / Administration** | 5 | 0.119 | 0.015 |
| 10 | **BIM/CAD** | 6 | 0.114 | 0.010 |
| 11 | **M&E Design** | 11 | 0.109 | 0.009 |
| 12 | **Commercial Management** | 10 | 0.104 | 0.011 |
| 13 | **Construction Management** | 4 | 0.092 | 0.008 |
| 14 | **Document Control** | 4 | 0.085 | 0.007 |
| 15 | **Geotechnics** | 4 | 0.076 | 0.005 |
| 16 | **Sponsor** | 1 | 0.071 | 0.004 |
| 17 | **Assurance** | 1 | 0.068 | 0.003 |
| 18 | **Operations** | 2 | 0.063 | 0.002 |
| 19 | **Utilities Management** | 3 | 0.059 | 0.001 |
| 20 | **Environment** | 1 | 0.057 | 0.001 |
| 21 | **Client Interface / Stakeholder Engagement** | 2 | 0.053 | 0.002 |
| 22 | **Legal / Contractual** | 1 | 0.050 | 0.001 |

### 4.3 Stage 2: Integrated Delivery Governance

Stage 2 analysis (Table 4) highlights a major reconfiguration of governance authority. Architectural Design and Design/Engineering Management emerged as the most central functions, surpassing Civils & Structures. Their rise reflects a transition toward integrative design delivery and multi-disciplinary coordination, which is a characteristic of adaptive governance in mature project phases (Pitsis et al., 2003).

Furthermore, Project Management also gained prominence, reflecting the redistribution of authority from discipline-based managers to project-level delivery coordinators. Notably, Quality, Systems Engineering, and BIM/CAD rose to central brokerage roles, underscoring the increasing importance of integrative, assurance, and digital functions in shaping collaborative governance spaces. These actors exemplify hidden and invisible forms of power. That is, their influence derived not from formal authority but from control over knowledge/information flows, integration mechanisms, and collaborative tools.

Meanwhile, Civils & Structures retained influence but no longer dominated governance, operating instead within a more balanced and distributed network. Functions such as M&E Design and Tunnelling also gained greater engagement, while Risk Management and Health & Safety, once prominent hidden brokers, became less central. This reflects a governance environment shifting from discipline-based risk assurance toward integrated delivery oversight.

In PowerCube terms, Stage 2 shows the expansion of invited spaces through design reviews, weekly breakfast meetings, integrated governance boards, and BIM-enabled collaboration. In this stage, invisible power becomes more salient, as actors like Quality and Systems Engineering shape outcomes through legitimacy, assurance, and knowledge integration. Figure 4b visually illustrates this diffusion of influence across multiple hubs, contrasting with Stage 1's concentration.

In line with Q1, this stage demonstrates a marked reconfiguration of actor influence, and in response to Q2, it shows that governance implications included the redistribution of authority, the rise of integrative functions, and the growing role of invisible power in shaping decision-making. These findings reinforce the study's central aim of understanding governance as a dynamic and evolving process in which legitimacy and authority are continuously renegotiated among actors. Moreover, the methodology's functionality is evident, as the temporal comparison of network metrics made it possible to trace these shifts, while the PowerCube dimensions contextualised them as movements between visible, hidden, and invisible forms of power.

**Table 4:** Stage 2 functional governance summary (ranked by average degree centrality.

| Rank | Function | Number of Actors | Avg Degree Centrality | Avg Betweenness Centrality |
|---|---|---|---|---|
| 1 | **Architectural Design** | 9 | 0.236 | 0.033 |
| 2 | **Design/Engineering Management** | 19 | 0.170 | 0.025 |
| 3 | **Civils and Structures** | 14 | 0.168 | 0.023 |
| 4 | **M&E Design** | 19 | 0.150 | 0.007 |
| 5 | **Quality** | 3 | 0.146 | 0.090 |
| 6 | **Tunnelling Design** | 17 | 0.127 | 0.021 |
| 7 | **Project Management** | 12 | 0.121 | 0.023 |
| 8 | **Systems Engineering** | 10 | 0.121 | 0.008 |
| 9 | **BIM/CAD** | 11 | 0.111 | 0.005 |
| 10 | **Project Controls** | 11 | 0.105 | 0.010 |
| 11 | **Risk Management** | 1 | 0.092 | 0.000 |
| 12 | **Project Support/Administration** | 6 | 0.092 | 0.039 |
| 13 | **Commercial Management** | 22 | 0.085 | 0.004 |
| 14 | **Sponsor** | 2 | 0.079 | 0.008 |
| 15 | **Document Control** | 5 | 0.079 | 0.012 |
| 16 | **Construction Management** | 8 | 0.070 | 0.009 |
| 17 | **Assurance** | 1 | 0.041 | 0.000 |
| 18 | **Geotechnics** | 7 | 0.036 | 0.003 |
| 19 | **Operations** | 2 | 0.036 | 0.000 |
| 20 | **Environment** | 1 | 0.026 | 0.000 |
| 21 | **Health and Safety** | 3 | 0.024 | 0.000 |
| 22 | **Utilities Management** | 7 | 0.022 | 0.000 |
| 23 | **Track Design** | 1 | 0.020 | 0.000 |
| 24 | **Utilities Design** | 3 | 0.010 | 0.000 |
| 25 | **Logistics Management** | 1 | 0.010 | 0.000 |
| 26 | **Consents Management** | 2 | 0.005 | 0.000 |

### 4.4 Comparative Governance Shifts

The comparative mapping (Table 5) illustrates the governance transformation between Stage 1 and Stage 2. Three key shifts stand out:

- **Redistribution of Authority:** Centrality shifted from technical dominance (Civils & Structures) to integrative brokers (Architectural Design, Design/Engineering Management, Systems, Quality, BIM). This reflects adaptive governance's emphasis on polycentric authority and collaborative problem-solving.
- **Expansion of Governance Spaces:** Governance moved from closed technical hierarchies in Stage 1 toward more invited and participatory arenas in Stage 2, including workshops, BIM reviews, and delivery coordination boards. This aligns with PowerCube's spatial dimension, highlighting the opening of governance spaces to broader participation.
- **Shift in Power Forms:** Stage 1 was dominated by visible technical authority, supplemented by hidden brokers. By Stage 2, hidden and invisible forms of power became more influential, as integrative and assurance functions shaped outcomes through brokerage and discursive legitimacy.

Together, these shifts show a clear adaptive governance pathway. The project evolved from a functionally segmented, closed model of governance to a distributed, polycentric, and participatory system. This reinforces Flyvbjerg's (2023) call for megaproject governance to move beyond rigid hierarchies, demonstrating instead how relational and temporal dynamics enable more adaptive arrangements.

This comparative analysis speaks directly to Q2 by revealing the governance consequences of evolving power relations, and to Q3 by showing that adaptive mechanisms — such as invited governance spaces, integrative design roles, and collaborative tools — provided practical pathways for managing shifting power configurations. By doing this, the study validates the effectiveness of the methodological approaches used: combining Social Network Analysis with PowerCube allowed not only the identification of changing coalitions but also showed how these changes impact governance effectiveness. This combination therefore supports the main goal of the article, which is to enhance the study of project governance by highlighting that power and authority should be considered as dynamic, relational processes.

**Table 5:** Comparative shifts in functional governance between Stage 1 and Stage 2 (Source: Original)

| Function / Role | Stage 1 (Design Coordination) | Stage 2 (Integrated Delivery) | Interpretation (Decision-Making Authority & PowerCube) |
|---|---|---|---|
| **Civils & Structures** | Rank 1 – dominant hub with highest centrality | Rank 3 – still strong but no longer dominant | Authority shifted from technical dominance (visible power in closed spaces) to shared influence within delivery governance. |
| **Project Controls & Project Management** | Rank 2 – key coordinators across functions | Project Mgmt rank 7; Controls rank 10 | Decline shows redistribution of authority from monitoring/control toward integrative and collaborative brokers. |
| **Architectural Design** | Rank 7 – peripheral role | Rank 1 – most central function | Rise reflects growing authority of integrative design disciplines; new invited spaces enabled broader participation. |
| **Design/Engineering Management** | Not central in Stage 1 | Rank 2 – highly central | Emerged as a key governance broker, shifting authority to cross-functional coordination (hidden power via integration). |
| **Systems Engineering** | Rank 6 – peripheral | Rank 8 – influential broker | Increased authority in delivery stage reflects invisible power of systems thinking and integration. |
| **Quality** | Rank 8 – small, hidden broker | Rank 5 – high centrality, strong betweenness | Authority shifted toward assurance and standards; hidden brokers became central, embodying adaptive governance resilience. |
| **BIM/CAD** | Rank 10 – peripheral technical support | Rank 9 – influential broker | Rise shows digital tools as governance spaces; hidden/invisible power shaping collaboration. |
| **Risk Management & H&S** | Ranks 4 & 5 – hidden brokers with high betweenness | Risk rank 11, H&S rank 21 – less central | Early authority in safeguarding/assurance diminished as governance shifted toward delivery integration. |
| **M&E Design** | Rank 11 – peripheral | Rank 4 – highly central | Shift shows authority redistribution to services coordination, reflecting cross-functional invited spaces. |
| **Operations** | Rank 18 – peripheral | Rank 19 – still peripheral | End-user authority remained limited, indicating invisible power not yet fully integrated. |

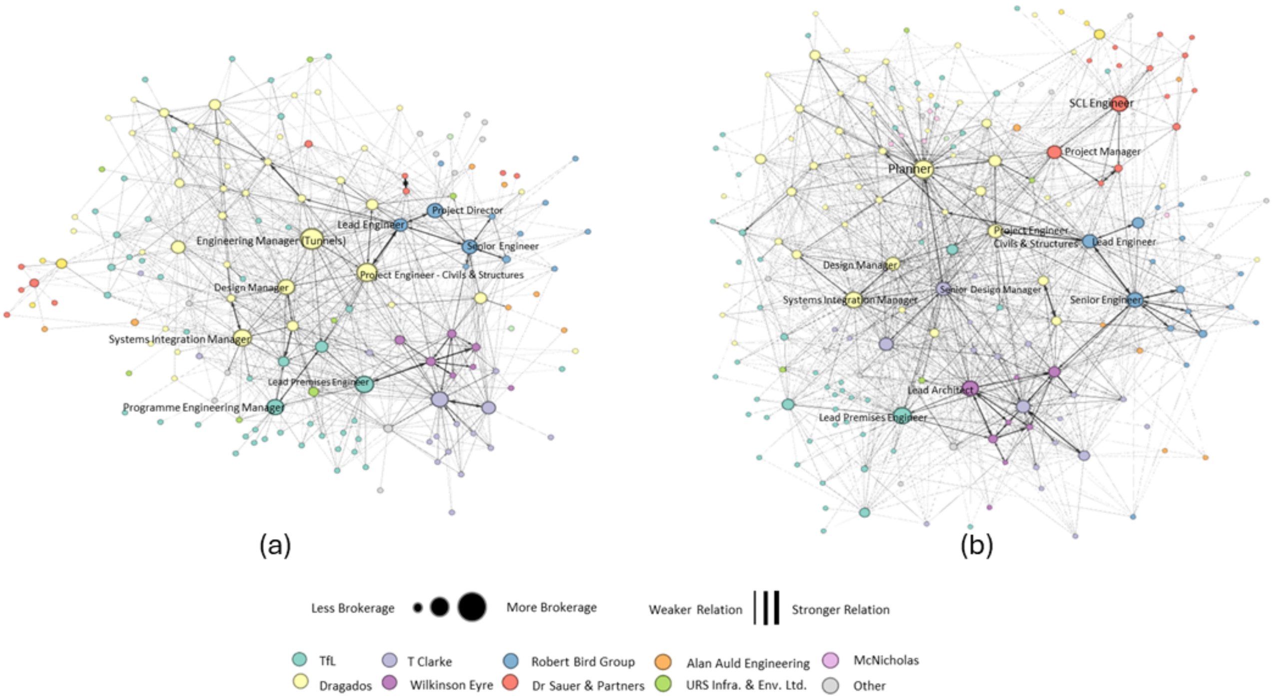


**Figure 4**. BSCU project network graph based on betweenness-centrality: (a) Network graph for stage 1 of the project; (b) Network graph for stage 2 of the project (Source: Original).

Taken together, the findings address the three research questions while advancing debates in urban management. First, Q1 is answered by showing how power relations evolved over time, shifting from discipline-based dominance in Stage 1 to polycentric, integrative governance in Stage 2. This dynamic evolution supports the argument that urban infrastructure governance must be understood as relational and adaptive rather than static (Flyvbjerg & Gardner, 2023; Brunet, 2019). Moreover, Q2 is addressed by demonstrating the governance implications of these shifts, particularly their impact on legitimacy and decision-making authority, aligning with the journal's focus on the institutional and managerial processes that shape urban development (Gaventa, 2006, 2019). Finally, Q3 is answered by identifying adaptive strategies, such as early contractor involvement, relational contracting, and collaborative governance boards, that enabled the project to accommodate shifting power relations, reinforcing adaptive governance as a practical necessity in complex urban infrastructure (Pitsis et al., 2003; Folke et al., 2005). Importantly, the integrated methodological approach proved functional in capturing the evolving structure of actor influence (Borgatti, 2005; McCulloh & Carley, 2009), and contextualizing these shifts within visible, hidden, and invisible dimensions of power (Pantazidou, 2012; Gaventa & Martorano, 2016). These insights collectively contribute to the journal's thematic interest in how governance mechanisms shape urban management outcomes, providing both theoretical insights and practical lessons for handling power and legitimacy in major infrastructure projects.

## 5. Conclusion

This study demonstrated that megaproject governance is not a static arrangement that can be defined from the outset of a project, but evolves over time as power networks shift. By combining temporal SNA and the PowerCube framework, it offers a new methodological approach to exploring how different forms of power—visible, hidden, and invisible—interact over time. Supporting the research aim and guiding questions, the findings confirm that governance in complex urban infrastructure projects is dynamic and relational, requiring continuous adaptation and renegotiation. The BSCU case demonstrates how changes in stakeholder centrality can disrupt hierarchies, create new coalitions, and reshape governance outcomes.

The findings carry three sets of implications. Theoretically, they contribute to debates on adaptive governance by demonstrating how PowerCube's dimensions (levels, spaces, forms) change dynamically as projects move from functionally driven to delivery-driven governance. From a practical standpoint, they illustrate that power should not be viewed only as a constraint or threat but as a potential resource that can be leveraged to develop adaptive strategies and foster collaborative opportunities. That is, practitioners should think counter-intuitively about power, including the way it operates relationally among the less powerful through clusters and coalitions. This offers actionable insights for urban managers and policymakers seeking to improve legitimacy, adaptability, and stakeholder engagement in complex project environments. Methodologically, the study contributes a novel integration of PowerCube and SNA, moving beyond static applications to demonstrate how network structures can operationalize power dynamics longitudinally. This illustrates the functionality of the combined approach, showing how temporal mapping of actor relations can be paired with multidimensional power analysis to capture evolving governance processes.

In line with Flyvbjerg's (2023) observation that megaproject governance must move beyond rigid hierarchies, this study shows how hybrid analytical approaches can uncover the adaptive pathways required to respond to evolving power asymmetries. More broadly, it offers transferable insights for urban management scholarship and practice, aligning with the journal's thematic interest in how governance mechanisms shape decision-making and outcomes in cities and infrastructure systems.

Nonetheless, the study has limitations. Combining SNA and PowerCube requires complex data collection, careful contextual interpretation, and interdisciplinary collaboration. Coding relational data into power categories inevitably involves some degree of subjectivity. Future research should address these challenges by refining hybrid methodologies, expanding to multi-case and cross-sectoral studies, and developing tools to better capture the multidimensionality of power across levels, spaces, and forms. Such efforts would further enhance the generalisability of findings, advancing both urban management research and supporting practitioners in navigating the governance complexities of large-scale infrastructure.

**Acknowledgements**

The author sincerely thanks everyone that has contributed to this study.

**Funding**

This research received no external funding.

**Conflicts of Interest**

The Authors declare that there is no conflict of interest.

**Data availability statement**

The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

**Institutional Review Board Statement**

Not applicable.

**CRediT author statement:**

The author confirms sole responsibility for all CRediT roles.

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