Design boundary dynamics in infrastructure projects: Issues of resource allocation, path dependency and problem-solving

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Abstract

Due to their complexity and high social impact, urban infrastructure projects often face challenges in managing the design decision-making processes across disparate disciplinary and knowledge domain boundaries. This paper introduces the notion of *design boundary dynamics* to describe the various cross-boundary coordination phenomena associated with organising the design of infrastructure projects. Taking a practice-based theoretical stance, the paper presents findings of qualitative research on the nature and genesis of design boundaries and their relation to the strategic decision-making on a transportation infrastructure project. Findings illustrate the entangled processes, through which the disciplinary, knowledge-domain and stage-based design boundaries emerged as a result of unfolding project practices. Paper identifies the key role of resource allocation constraints, path dependency of project decisions, and problem-solving nature of design and concludes with strategic recommendations for upstream operational integration to mitigate the impact of design boundary dynamics on infrastructure projects.
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1. Introduction

There has been an increasing appreciation of the role that infrastructure projects play in the development of local and national economies. Very often, these infrastructure projects result in fixed assets whose main role is to facilitate the society as a whole to capture value from everyday economic and social activities. The complexity of the social and economic functions that infrastructure performs is also reflected in the organisation that delivers the project to the users. These complex organisations are sometimes referred to as complex project coalitions involving diverse user groups and communities that possess the power to determine the faith of a project, if they disagree with its goals (Morris, 1994; Winch, 2010). Because of the high social and economic impact coupled with very long life-cycles of infrastructure, decisions made in early stages of the project development pipeline will shape not only the physical outline and functionality of the asset but ultimately also the quality of the operations being delivered to the public by means of infrastructure (Brady and Davies, 2010; Gil and Tether, 2011). In a traditional project lifecycle context, these high-impact decisions are often attributed to the planning and design processes of infrastructure development. Despite the obvious importance of these knowledge-intensive decision-making processes, there is surprisingly little research that addresses design issues encountered in infrastructure projects (e.g., Gil and Baldwin, 2014). Such design issues are often attributed to the various boundary phenomena that emerge across various knowledge domains in a typical infrastructure project coalition comprising diverse expert and stakeholder groups.

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Previous research suggests that it is the role of project managers to facilitate project integration across internal and external boundaries of complex projects (Davies and Mackenzie, 2014; Davies et al., 2009). Extant project research has also begun addressing some aspects of boundary phenomena in project organisations, for example the role of project management in knowledge transfer across projects and the parent firm (e.g., Pemsel and Wiewiora, 2013) or the role of boundary objects in mediating collaboration across knowledge domain boundaries within projects (e.g., Chang et al., 2013). Although existing research provides valuable insights on boundary practices in projects, it by and large takes for granted that boundaries exist as a structural feature of the project scope and its disciplinary knowledge features. Furthermore, existing research largely takes the positivist stance, in which project boundaries are understood as static, forming a structure that will stay in place throughout the project. At the same time, very little is known about the dynamic nature of internal boundary phenomena that emerge, change, and unfold over time as well as how they inform decision-making about courses of action to be taken (Langley et al., 2013). The aim of the study is to address this gap and better understand the challenges that occur due to knowledge interactions across disciplinary and knowledge domain boundaries on infrastructure projects. In other words, the purpose of the study is to tackle the *design boundary dynamics* as a key precursor of managing infrastructure projects. To this end, the study will adopt the stance that the internal boundary phenomena can be studied as they are made sense of by the practitioners who at the same time decide about different courses of action for the project. As a result, the study focuses on practitioners' perceptions as the primary figure of discourse.

The study specifically aims to address the following research question: *How can the genesis of design boundary dynamics in infrastructure projects be understood in the context of strategic decision-making?*

The focus on boundary dynamics is in stark contrast with most extant project research that conceptualises boundaries as a structural, and thus static, feature of project organisations. The value of such a contribution is aligned with the recent call for more research on social interactions and practices in projects as opposed to a more traditional focus on project structures and performance (Floricel et al., 2014). Espousing the situational practices and their lived perceptions on behalf of the practitioners involved would also be a way to overcome the main shortcomings of traditional organisational research based on the paradigm of positivist rationality (Sandberg and Tsoukas, 2011). To address this need, the paper will next draw upon research on design, work practices and sensemaking in the camps of organisational theory and project studies to derive a theoretical framework for the analysis that will follow.

The paper is structured as follows. The following section lays out a selection of design and practice-based studies in management and organisation research as well as the practice turn in project research as the basic theoretical framework for the inquiry. The paper then turns to boundary-related studies in the domain of mainstream organisation and project studies to elaborate the analytical level of analysis for this research.

The paper continues with an exploratory study on the genesis of design boundary dynamics in infrastructure projects. This argument is developed through an analysis of exploratory interviews that expose how the selected highly-knowledgeable informants on the case project made sense of design boundary dynamics in project practices with the benefit of hindsight. After presenting the exploratory study, the main findings will be discussed by integrating conceptual ideas from design, boundary and practice theory to derive implications of the study for project practitioners. The paper will conclude with limitations and directions for future research in this area.

2. Making sense of design practices

Research on design has a remarkably long and productive history of generating insights with broad-ranging interdisciplinary impact. For example, early design research has laid the groundwork for the seminal theoretical constructs now commonly referred to as *bounded rationality* (Simon, 1969/1996) as well as *reflective practice* (Schön, 1984). More recently, design has been defined through the concepts of cognitive problem-framing leading up to the corresponding problem-solving activity (Dorst, 2011). Drawing upon this body of design research, we can talk about design activity in practical terms as a combination of problem formulation, solving and decision-making practices leading up to distinct courses of action on projects (Zerjav et al., 2013).

The focus on micro-agency, problem-solving and decision-making activities makes design particularly conducive to practice-based theoretical interpretations. The origins of practice-based research in project studies can be traced to the so called *practice turn* in humanities and social research (Schatzki et al., 2001), a concept that has been extensively permeating the mainstream organisation and management research community in the last decade. The fundamental premise in this stream of theorising is that traditional strategy research has focused on the macro-level structures of organisations leading to concepts, which although might be plausible for management practitioners, they are highly-abstract and divorced from the level of activity that enacts the organisational reality (Jarzabkowski and Spee, 2009; Whittington, 2006). As a result, an increasing amount of research is focused on the discursive and material nature of day-to-day practices in organisations (Denis et al., 2007; Hardy and Thomas, 2013).

Concurrently with the practice turn in strategy research, a similar development can be noticed in recent project studies. Origins of the practice-based project studies can be traced to the behavioural school of thought in early project management (Söderlund, 2011), but only relatively recently has this movement gained prominence in the mainstream project literature. These studies, for example, argue that a focus on what people actually *do* in projects rather than what they *should do* would help in resolving the relevance issue, a shortcoming that has often been attributed to the traditional positivist project management inquiry (Blomquist et al., 2010; Bresnen et al., 2005; Cicmil and Hodgson, 2006; Cicmil et al., 2006; Smyth and Morris, 2007). By drawing upon pragmatist philosophy, in particular John Dewey,