



A framework for examining the dimensions and characteristics of complexity inherent within rail megaprojects

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Received 22 December 2015; received in revised form 27 April 2016; accepted 3 May 2016
Available online 19 May 2016

Abstract

This paper presents a framework for examining the *dimensions* and *characteristics* of project complexity, with an emphasis on rail megaprojects. UK government departments have recorded that project complexity has increased significantly over the last decade and highlight that the subject has received inadequate attention, with a detrimental effect on project performance. However departments have not examined the *characteristics* of complexity or made a distinction between complexity emanating from the decisions made by the project itself and the complexity emanating from its context, as they warrant different treatment. By way of response, post examination and comparison of existing frameworks, a new framework is proposed based on a literature review. A case study is examined to illustrate how the framework may be applied.

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Keywords: Complexity; Complicated; Megaprojects; Model; Rail; Risk; Uncertainty

1. Introduction

We live in an age of megaprojects. The goals, scale, duration, cost and risk exposure of projects in the UK and internationally have grown dramatically over time. These megaprojects typically attract high levels of both public and political interest due to their cost and their impact on the environment, ecology, economy, neighbouring communities and property-owners. However as described in the literature, while an increasing number of large infrastructure developments are being undertaken around the world, the record of performance of these projects is poor (Flyvbjerg et al., 2003a). These ambitious projects have commonly been associated with cost overspend, delays and or shortcomings in scope and quality, (Flyvbjerg et al., 2003b). Analysis of 258 projects found that nine out of ten transportation projects exceeded their budget and for rail projects the average cost escalation was 45% (Flyvbjerg et al., 2004). As a consequence there is a perpetual search for methods aimed at reducing uncertainty, managing risk and improving

project performance. One of the avenues of enquiry which has been receiving growing attention is the contribution of complexity to poor project performance. In addition the literature makes frequent reference to the belief that the degree of complexity is increasing (Baccarini, 1996; Braglia and Frosolini, 2014; Flanagan and Jewell, 2005; Gidado, 1996; Hillson and Simon, 2007; Loosemore et al., 2003; Vidal and Marle, 2008; Walker, 2002; Wideman, 1990; Williams, 1999). The UK National Audit Office infers that there is a direct cause-and-effect relationship between projects' lack of comprehension of complexity and poor project performance (NAO, National Audit Office, 2013b). While UK government departments emphasise the significance of complexity there is not a commonly accepted definition. Without a broadly accepted definition accompanied by a consensus on the source, characteristics, implications and evolving nature of complexity, this cause-and-effect relationship is difficult to articulate and subsequently address. Given the goal of understanding and managing complexity to improve project performance, it is proposed that a clear distinction is made between project complexity emanating from aspects under a project's direct control and complexity emanating from a project's context. If a project deliberately and consciously elects to incorporate novel technologies, adopt an

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untried contracting strategy and or significantly subdivide the works thereby increasing the number of interdependencies, by its actions it will have in all probability introduced complexity and a greater management burden. The aim of this paper is to present a project complexity framework (reflecting existing frameworks) as a vehicle to examine the common *characteristics* of complexity with an emphasis on transportation projects. Additionally the aim of the paper is to highlight the imperative that sponsors and project managers need to understand and manage the aspects of complexity as several UK government major projects (which paid inadequate attention to complexity), missed their objectives as a result. The framework is applied to a case study of the High Speed Two railway project to understand the merit of its further development. The contribution this paper makes is the presentation of a complexity framework which goes beyond existing frameworks in that it considers the dynamic nature of projects. It considers for instance the evolving maturity of project management practices, the application of assurance processes and the adaptation of project governance to suit the needs of a project overtime. In addition emphasis is placed on those aspects of complexity under the control of the project and those emanating from its environment. The framework is focussed on rail projects and examines complexity *characteristics* relating to this industry.

2. Literature review

The following paragraphs provide an overview of project complexity prior to proposing a framework of the aspects of complexity to aid the analysis of rail megaprojects: definition of project complexity, complex or complicated, complexity is not a static notion, the perceived importance of complexity in the UK, initiatives to examine and manage the sources of complexity and project complexity stems from uncertainty.

2.1. Definition of project complexity

The [Collins English Dictionary \(2015\)](#) defines complexity as “the state or quality of being intricate or complex” where complex is defined as “made up of various interconnected parts”. While a number of writers have offered a definition of complexity there is no consensus or commonly adopted definition of what it is, ([Bosch-Rekvelde et al., 2011](#); [Fitsilis and Damasiotis, 2015](#), [Ochieng et al., 2013](#), [Parwani, 2002](#); [Vidal et al., 2011](#)). It could be anticipated that definitions would be proposed by writers based on the perceived *characteristics* of complexity. [Baccarini](#) for example refers to complexity as “consisting of many varied interrelated parts” which can be described in terms of their degree of differentiation and interdependency, ([Baccarini, 1996](#)). The APM describe a complex project as one which will typically involve interaction between several organisations and or different units in the same organisation requiring the coordination of the work of several disciplines and involve a wide range of project management methods, tools and techniques ([APM, Association for Project Management, 2008](#)). The Major Projects Authority, within their 2013/2014 annual report, describe major projects as complex and ambitious and refer to the challenges of the introduction of new technology, organisational structures and

private sector procurement methods ([MPA, Major Projects Authority, 2014](#)). The introduction of novel untried approaches introduces uncertainty. If it is accepted that complexity arises not from what is known and under control, but what is uncertain and unpredictable, as proposed by [Turner and Cochrane \(1993\)](#), then a definition of a complex project warranting examination would be “a complex project is one which exhibits a high degree of uncertainty and unpredictability, emanating from both the project itself and its context”. Aspects of project uncertainty emanating from within the project itself include uncertain goals and scope, the adoption of novel technology, together with the choice of organisational structure, project management method and contracting strategy. Until and how they are resolved would impact project performance. Aspects of uncertainty emanating from the context of particular interest include the external stakeholders’ evolving expectations, definitions of project success and the relationships between them. Specifically uncertainty will exist from the behaviour of the stakeholder representatives and how they interact with each other and the project team.

2.2. Complex or complicated

The terms ‘complex’ and ‘complicated’ are labels that are often used interchangeably to describe tasks that are intricate or problematical, as if they were synonymous ([Geraldi et al., 2011](#)). However to advance our understanding of complexity it is important to draw a clear distinction between the two ideas, as “complex” is not the same as “complicated” ([Maylor et al., 2008](#); [Whitty and Maylor, 2009](#)). A complicated project while large in scale may be largely ‘self-contained’, comprehensible and managed by an organisation so that is highly predictable and runs like clockwork. By way of an example, while the design and installation of the many kilometres of wiring on the Boeing 777 aircraft was complicated, it was describable and ultimately knowable. A complex project however typically has an ever-changing unpredictable political, economic and societal environment with hundreds or even thousands of reciprocal ties. It has stakeholders that can impose radical change and who do not respect and may even oppose existing decisions, schedules, procedures or strategies. An example of a complex project is the Boston central artery / tunnel project (commonly known as the ‘Big Dig’) as the project could not be fully understood simply by analysing its components due to the unpredictable interaction between the project and its environment and between one external stakeholder and another ([Chapman, 2014a, 2014b](#)). This distinction is important when seeking to understand the uncertainty associated with complex projects.

2.3. Complexity is not a static notion

The perception of what is considered complex changes with the passing of time. Many activities or projects appear to be complex when they are first undertaken but as experience, knowledge and understanding grows and they are followed by more ambitious projects, they appear less and less complex. Consider for a moment Stonehenge ([Green, 1997](#)), St Pauls Cathedral and similar structures ([Kozak-Holland and Procter,](#)

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