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Project risk management and design flexibility: Analysing a case and conditions of complementarity

Nuno Gil[a,*], Bruce S. Tether[b]

[a] *Centre for Infrastructure Development, Manchester Business School, United Kingdom*
[b] *Imperial College Business School, United Kingdom*

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ABSTRACT

We explore how risk management and design flexibility interplay in major (infrastructure) projects, using the £4.2bn Terminal 5 project to expand London's Heathrow airport. By juxtaposing these two conceptual frames, we unearth the conditions under which they can be complements for managing the tension between efficiency and effectiveness central to these projects. Building design flexibility – through modular or safeguarded integral architectures – increases adaptability to accommodate evolving requirements which is necessary to attain effectiveness. Efficiency, in turn, demands risk management to deliver the project 'on time, within budget'. We explain variation in the interplay between the two approaches, highlighting the moderating role of the developer's relationship with the customer. Strong co-operation, particularly in a stable environment, encourages investments in design flexibility. Risk management practices prevail when co-operation breaks down. Another insight is that co-location and continuity of key project staff are themselves inadequate conditions to sustain co-operation.

1. Introduction

Large-scale infrastructure assets such as an airport terminal, power station, or high-speed rail line are delivered through one-off, multi-year, capital- and engineering-intensive projects. The symbiotic relationship between the developer, who incurs the capital costs, and the customer(s) who will operate the asset, is central to these projects. Because customers' needs evolve over time, they understandably want process flexibility to postpone design decisions and request late changes. But keeping the design fluid during physical execution is challenging, as gains in the effectiveness of the final asset may come at the cost of lost efficiency in project delivery, increasing the time and/or cost required for project completion. Hence, this tension between efficiency and effectiveness is a key characteristic of large infrastructure projects, and of large engineering (major) projects more generally (Morris, forthcoming).

The risk management literature applied to major projects has recognised this tension. Scholars recognise that adapting the project to changes in customer needs can be business critical (Dvir and Lechler, 2004; Gil et al., 2006; Miller and Lessard, 2000). To decide whether to accede to a customer's re-design request, project teams are urged to appraise and manage the risks of adapting the elements that are under detailed design or construction, as well as those elements that have been completed (Cleland and King, 1983; Cooper and Chapman, 1987; Morris and Hough, 1987). Changes are typically accepted when their prospective benefits to future operations are thought to outweigh the adaptation costs and risk of delays, which can both be significant, especially in projects with integral design architectures (Shenhar, 2001; Floricel and Miller, 2001).

Extraordinarily, however, the development of project risk management has barely intersected with studies on commercial new product development, which consider the comparable problem of achieving efficiency whilst attaining consumer satisfaction. In this world, scholars advocate the use of modular architectures to achieve flexibility and substitute risk management under uncertainty (Thomke, 1997). Modularity enables set-based design and mass customisation practices, both of which permit a range of final products to be offered to consumers within the scope of the flexibility deliberately built into the architecture (Pine II, 1993; Sanchez, 1995; Sobek II et al., 1999; Clark and Fujimoto, 1991; Ward et al., 1995; Feitzinger and Lee, 1997; Iansiti, 1995). Design modularity also enables developers to exploit product platforms over their lifecycle (Sanderson and Uzumeri, 1995; Martin and Ishii, 2002) and to postpone design freeze to incorporate cutting-edge technologies for which premium prices can be charged (Iansiti, 1995).

To explore how risk management and product design flexibility interplay in major projects, we undertook an inductive, multiple-case study of the £4.2bn (in 2005 prices) Terminal 5 (T5) project to

* Corresponding author.
E-mail addresses: nuno.gil@mbs.ac.uk (N. Gil), b.tether@imperial.ac.uk (B.S. Tether).

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expand London's Heathrow airport. Designed to handle 35 million passengers per year, BAA, the private owner–operator of Heathrow airport, began planning T5 around 1989. Planning consent was granted in 2001, and schematic design and construction began concurrently in September 2002. T5 opened 'on time and within budget' in March 2008. Our research design focuses on a key unit of analysis: co-design processes. We examined co-design processes for selected functional elements across different subprojects that involved the BAA's T5 team (the 'developer') and three separate future operators, the project customers.

Our key contribution is a theoretical, longitudinal understanding of the conditions under which risk management and design flexibility can complement each other for managing the tension between efficiency and effectiveness in major projects. Critically, we find that the developer's willingness to invest in design flexibility – through modular or safeguarded integral architectures – is moderated by the extent the developer and customer co-operate effectively during the project. Effective co-operation encourages investments in design flexibility, whereas poor inter-relations encourage the realisation of a more rigid architecture. The lack of product flexibility increases the costs and risks of adapting the design to accommodate evolution in customer needs, shifting the emphasis toward project risk management. Interestingly, we show co-location and continuity of key project personnel are insufficient conditions to achieve and sustain effective cooperation.

2. Background: project risk management and design flexibility

That performance is related to both achieving specified goals on time and within budget, as well as meeting customer requirements, is a notion central to both the management of major projects and to commercial new product development. In these two worlds, however, two largely separate frames have developed as to how to manage the design process: risk management and design flexibility. Risk management, particularly in relation to budget and schedule overruns, is central to the literature on the management of major projects. It is also fundamental to 'best practice', as championed by the professional project management institutions (PMI, 2004). In these projects, risks are influenced by three main factors (Morris, forthcoming).

First, is the importance of 'front-end strategizing'. This notion exhorts developers to invest time and effort at the project outset thinking through alternative scenarios that might affect design requirements. Seminal studies on managing risk stress the importance of prescriptive activities including defining the project scope and tasks; identifying risks, their likelihood and potential impacts; and planning contingent actions and budgets to counter impacts (Cleland and King, 1983; Cooper and Chapman, 1987). Scholars have also advocated combining prescriptive tasks with other up-front activities, such as scenario planning, options reasoning, talking to end-users/communities, and discussing the politico-economic environment with key project stakeholders (Morris and Hough, 1987; Morris, 1994; Miller and Lessard, 2000). Front-end strategizing aims to reduce the occurrence of 'strategic surprises' (Floricel and Miller, 2001) and 'goal changes' (Dvir and Lechler, 2004), but it cannot eliminate uncertainty in design requirements during the project's lifecycle.

Second, is the inevitability of unforeseen – and often unforeseeable – events occurring and affecting the project, regardless of the effort invested in front-end strategizing. To mitigate the risks arising from late adaptation, especially when many design variables interact, project teams are urged to build capacity to re-plan through test-driven iteration, 3-D modeling and rapid prototyping, and to pursue multiple solutions concurrently (De Meyer et al., 2002; Sommer and Loch, 2004). Scholars also exhort developers to invest in relational forms of contracting with suppliers, as these commercial arrangements encourage co-operative behaviour that translates into commitment, shared goals, and flexibility to cope with late changes in design requirements (Stinchcombe and Heimer, 1985; Clegg et al., 2002; Gil, 2009; Henisz and Levitt, 2009).

Finally, is the need to manage customers' behaviour and expectations. Customers can unnecessarily disrupt project execution by insisting on design changes, particularly when these are made late, and/or could have been foreseen and therefore incorporated into the design earlier (Shapiro and Lorenz, 2000). Customers often violate the project process without fully realising the implications of their behaviour for the project's progress and budget (Genus, 1997; Geyer and Davies, 2000). Aware of these issues, Hobday (2000) suggests that project administrators' needs should outweigh the influence of functional managers and customer directors. Others recommend setting up governance structures that make explicit the cost of late design changes (Ross and Staw, 1986; Miller and Lessard, 2007). Clegg et al. (2002), meanwhile, advocate an 'alliance culture' fostered by frequent meetings with the customers to discuss how to accomplish a 'future perfect' outcome when 'planning is almost impossible'. This approach brings soft skills such as communication, emotional intelligence, leadership, and motivation to the fore (cf. Morris and Pinto, 2004; Doherty, 2008).

All of these practices concern managing project risks, rather than deliberately building product flexibility into the schematic design. In marked contrast, building flexibility into the product design through the use of modular architectures is central to the approach often used to reconcile efficiency and effectiveness in commercial new product development (Clark and Fujimoto, 1991; Sanderson and Uzumeri, 1995; Ulrich and Eppinger, 1995; Ward et al., 1995; Feitzinger and Lee, 1997; Thomke and Fujimoto, 2000). Here, close attention is paid to the product architecture, which is the 'scheme by which the function of a product is allocated to physical components' (Ulrich, 1995). Integral architectures exhibit complex mappings and tightly coupled interfaces between components. Modular architectures, by contrast, relate to Simon's (1962) concept of 'nearly decomposable systems'. They break apart complex systems into an array of functional components and a set of design rules that de-couple and standardize the interfaces between the components (Ulrich and Eppinger, 1995). Because modules may be multi-functional, Baldwin and Clark (2000) rather define modules on the basis of relationships, i.e., units whose structural elements are powerfully connected amongst themselves and relatively weakly connected to elements in other units. Modularity increases the possibility space for final designs provided these conform to the rules and integration protocols agreed upfront (Baldwin and Clark, 2000). Overall, when design flexibility is high, the cost and time required to keep the design fluid until close to market launch is low because one module can be modified with little or no impact on others (Thomke, 1997).

Product modularity is neither free nor easy to achieve, however (Baldwin and Clark, 2000, 2006; Whitney, 2004). In the absence of modularity, more limited flexibility can be incorporated through the use of 'safeguards' or buffers (Gil, 2007, 2009a), such as over-engineered foundations and conservative equipment choices, built into integral architectures. These design allowances aim to limit or suppress the ripple effects of foreseeable changes to one element to other interdependent elements, and accordingly, limit the costs of exercising the built-in options in a possible future. Yet, safeguarded architectures are also more expensive than those without built-in flexibility. Despite occasional calls for postponing design decisions (Gil et al., 2006) and for developing major projects in self-standing modules (Morris, 1994), empirical studies of how design flexibility is incorporated into major projects are very scarce. Anecdotal evidence suggest developers are interested in achieving flexible architectures, e.g., high-rises and car parks that can later accommo-