

LEAN LEADERSHIP IN MAJOR PROJECTS: FROM 'PREDICT AND PROVIDE' TO 'PREDICT AND PREVENT'

Structured abstract

Purpose: This paper contributes to the understanding of the context of major projects and their management from an Operations and Supply Chain Management (OSCM) perspective; we provide a foundation for exploring how the body of work on lean thinking (our '*old*' theory) can contribute to the development of major projects (the '*new*' context). In doing so, it extends the prevailing economic approach to major projects (best described as '*predict and provide*') and posits the development of an alternative approach based on extending the logic of lean thinking to this new context (referred to as '*predict and prevent*').

Design methodology / approach: The paper investigates the scope for adopting lean thinking in the context of major projects. To this effect we review the current state of both lean thinking and major project management, and use 'Universal Credit' as an exploratory case study to illustrate and verify our arguments in practice.

Findings: Two main findings are proposed: First, we demonstrate the inherent performance challenge of major projects in OSCM terms, which we argue presents a significant opportunity for the application of OSCM concepts to improve major project performance. Second, using lean thinking as framing, we identify three distinct process levels and common wastes in major projects, and identify five principles for how lean could improve the delivery of major projects.

Research limitations / implications: Major projects present a relatively untapped area for OSCM research; based on our exploratory case we propose ways how OSCM concepts can be applied to this new context. Further research will be needed to validate and generalise this application.

Practical implications: Major projects, including organisational transformations, IT-enabled change, major events and large infrastructure projects, constitute a large proportion of economic activity. Despite their prominence, however, they are also commonly associated with low success rates. This paper provides one route for exploring how a successful set of principles could be applied to improving their performance.

Originality / value: This work translates a popular set of ideas from OSCM to strengthening a relatively neglected context within OSCM. An agenda for further research is suggested to support the development of this application.

Keywords: Operations and Supply Chain Management practices; major projects; lean thinking; agile; theory of constraints; systems levels; leadership.

1 Introduction

Major projects, are temporary undertakings of a budgetary size, extent and managerial complexity that inherently make them a strategic risk to the organisation(s) undertaking them. These projects, programmes, megaprojects, complex projects or strategic initiatives, are hereafter collectively referred to as 'major projects', and include organizational transformations (as the result of mergers and acquisitions, or re(dis)organisation), IT-enabled change, infrastructure (e.g. high-speed rail, power plants), international events (e.g. Olympic and Paralympic Games), as well as 'big science' collaborations (e.g. the HADRON collider at CERN, or the International Fusion Project ITER). As such, major projects represent a significant field of economic activity. Global fixed capital formation (national undertakings such as roads, rail, dams, schools and hospitals) is largely carried out as projects and consumed US\$19 trillion in 2015 (World Bank 2016). Further, an estimated 35% of national GDP is generated by projects (based on Germany, Norway and Iceland, see: Schoper et al. 2018), with the UK government alone having a major projects portfolio of in excess of \$500bn and in-year spend of US\$40bn (IPA 2016).

So why should these endeavours be of interest to OSCM scholars? Major projects are a source of enduring challenge, with failure rates as high as 70% (Williams 2005; Merrow 2011; NAO 2015). Major projects are problematic therefore for the organisations that run them, their stakeholders and for those involved in their delivery. It is also widely acknowledged that the inherent complexity does not permit for the *exclusive* application of traditional project management tools (Geraldi et al. 2011). However, failure of a major project is rarely as simple as not meeting time or budget targets or not delivering planned benefits. A poor media report (e.g. UK press on Qatar's World Cup construction programme) can be as important to the perception of success as hard performance metrics. Success is as difficult to define as it can be elusive. Moreover, we see a 'failure of ambition' in delivery of projects, consistent with Hayes and Wheelwright's 'Stage 1' in their capability-maturity model (Wheelwright and Hayes 1985). Delivering early, under-budget and with enhanced benefits is less common as an objective than merely meeting pre-determined targets. Further, these 'targets' themselves are often set, without reference to either the assumptions behind them, or history. A recent example is the UK's Dreadnought Class ballistic missile submarine programme. The Secretary of Defence at the time, Michael Fallon MP, proclaimed on the day of the parliamentary vote on funding the programme, that the US\$ 50bn programme would be delivered 'on time and on budget' (The Times 2016). Considering the numerous and significant uncertainties included in the estimates for time and cost, such a statement is truly staggering: it neither recognises the inherent

uncertainties, nor does it show any ambition to improve cost and lead-time beyond this target.

In this paper we will revisit the traditional approach to managing major projects, best summarised as *predict and provide*, and will contrast it with an alternative view derived from applying OSCM theory to major projects, which we will refer to as a *predict and prevent* strategy.

We have used the term *lean leadership* because we posit that lean thinking – a concept derived from repetitive manufacturing - can equally be of value in a context where the overall system (project) is being designed and redesigned as the project progresses. Naturally there is a change in the work being done by the system because of the project lifecycle. For instance, in the concept stage, the work undertaken will be iterative and focused on information processing, whereas in execution, there will be less iterations and a mixture of materials, people, information and even organisations processed by the project system. In manufacturing, the assumption is one of stability and repetition in the process. We use Universal Credit (a major initiative by the UK government to merge all state benefit payments into a single payment) as an illustrative case to demonstrate the inherent performance challenge, to identify distinct operational levels within a major project, and to identify common wastes that can occur in its execution.

Based on our observations we propose a framework for how lean can enhance the practices associated with defining and delivering major projects; the integrative nature of this framework underpins the embedded leadership aspects. Whilst the tools of lean are important, we want to get away from a tools-based view of lean in projects. Just as Liker and Convis (2011) state, a great fallacy of the past has been the assumption that just adopting the tools will lead to the desired outcome. Therefore, we purposefully adopt the term *leadership* to show that what is required is a mindset that pervades throughout the major project, not limited to the task level. Furthermore, this represents a key aspect of organisational and operational design for the major project and therefore is part of the role of major project leaders. As such it falls under the heading of ‘technical leadership’ and given its strategic nature, is distinct from ‘managing’.

2 'Predict-and-Provide': The traditional approach to improving the delivery reliability of major projects

There is no shortage of analysis of the problems of major projects (notably: Flyvbjerg et al. 2003; Davies et al. 2017). Inspection of the analyses of government auditing bodies (e.g. UK's National Audit Office), scrutiny by powerful parliamentary committees (e.g. UK's Public Accounts Committee) and extensive commentary and review by consultants provide largely consistent findings of critical failure factors (CFFs). These rarely extend beyond the observations of Pinto and Kharbanda (1996) in their scope, and typically include ignoring the project environment, pushing a new technology to market too quickly, not bothering to build in fall-back options, and letting new ideas starve from inertia.

Prior analysis has widely demonstrated the extent and nature of the over-runs in major projects across a broad spectrum of industries (e.g. Jennings (2012) for Olympic and Paralympic Games; Ansar et al. (2014) for dams; Flyvbjerg and Budzier (2011) for IT-enabled change). A common thread in this analysis is the use of prospect theory (Kahneman and Tversky 1979) as theoretical basis, demonstrating the limits of rationality in decision making in major projects. This includes, for example, optimism bias that leads to understating costs and risks, and overstating benefits of value of the project (Flyvbjerg et al. 2003). A common cure for this optimism is the collection and analysis of data of the outcome of comparable projects to form a *reference class*. Justification of the budget for future projects then should include comparison of the expected costs and time with the appropriate reference class, allowing the uplift of cost and time estimate to the level of demonstrable performance elsewhere. This is one strategy for improving the compliance performance of major projects - termed *predict and provide*. The comparison with the reference class gives evidence of optimism bias, which can be corrected.

Consider Figure 1, which depicts the probability of an outcome (such as adherence to estimated budget or schedule) for a group of similar major projects. The core logic of *predict and provide* is to increase resources or lengthen the schedule to assure a certain higher level of probability of success: *P50* for example would predict that 50% of major projects in this reference class would reach completion by this cost or time, while *P80* indicates the cost or time at which 80% of similar projects reach completion. This links an estimated outcome to past experience, and provides a range of probabilities for the actual outcome.

In practice, estimates are typically submitted at a P50 level by the project team. In contrast, the required time and financial resources are considered at a P80 level, by many organisations. The difference between P50 and P80 figures is the *project contingency* or *safety margin*. In doing

so a buffer is provided that reduces the perceived variation in project outcome. By setting the bar for a project being claimed as a *success* at the P80 level, more projects should, in principle, achieve that success. However, amongst other objections, this approach fails to identify and address what caused this variation in the first place.

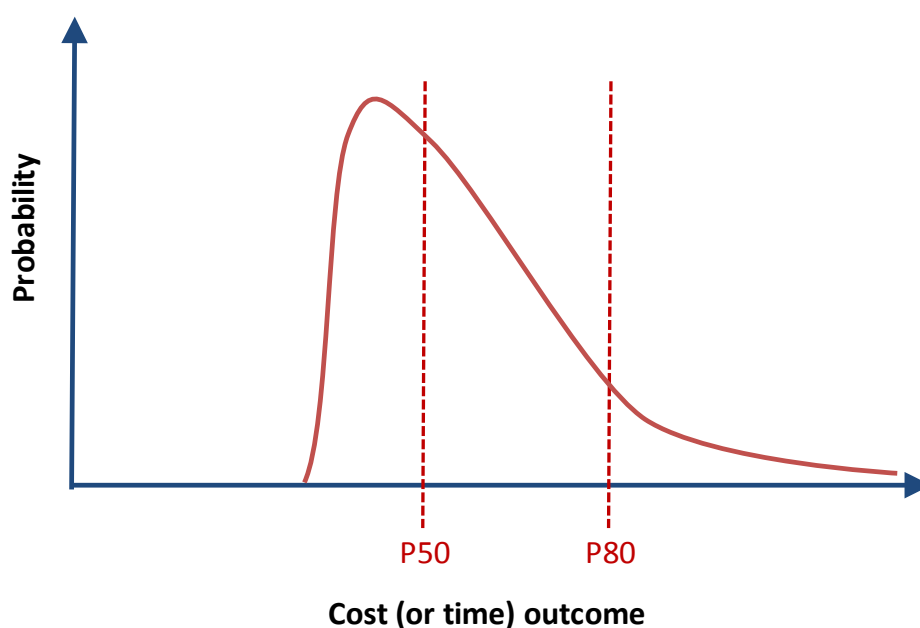


Figure 1: A graphical representation of using the past performance of similar projects to predict the likelihood of budget and schedule overruns.

As a strategy, this is nonetheless well established in practice (e.g. in UK Treasury ‘Green Book’). However, when one considers over-runs (whether defined as exceeding the P50 or otherwise) and then considers all the reviews and analysis undertaken by others, there are obvious and very significant wastes. These include rework, and failure to learn/improve. From a lean perspective, the strategy of *predict and provide* is like a car plant of old, increasing the footprint of the factory to accommodate larger rework and rectification areas to deal with quality problems. Lean thinking does not argue with the *prediction* of over-run or waste, but a central philosophy is *prevention* or *elimination* of that over-run or waste.

We argue that such a view is helpful to elucidate the presence of considerable failure and the failure modes of major projects. The economists’ view ascribes this as being at least partially due to the presence of strong behaviours in the project approval process, which contributes to

considerable optimism bias, strategic misrepresentation, or downright lying (Flyvbjerg et al. 2003). Whilst such analysis can make organisations aware of the performance of similar previous projects (prediction), it falls short of providing theoretical insights and concepts as to how to avoid shortfalls and improve future performance in major projects, beyond increasing the initial target times and costs. Such a fatalistic view of major projects is only partially helpful in as far as it does not lead to prevention. Indeed, it could be argued that it legitimises poor *future* performance as the data enshrines poor performance in the reference class. If accepted practices are followed in major projects, then the outcome will indeed follow the established patterns of performance.

In the remainder of this paper we posit that OSCM concepts in general, and Lean Thinking (Womack et al. 1990; Womack and Jones 1996; Womack and Jones 2005) in particular, offer considerable potential for an alternative strategy of prevention and improvement. In the terms of Wheelwright and Hayes (1985) it sets a higher-level objective for the project (e.g. redefine delivery), targets being *the best possible* rather than a *minimum standard* (compliance with pre-determined time cost and quality targets) by drawing on and integrating multiples bodies of work at multiple levels in the project.

3 ‘Predict and Prevent’: The OSCM approach to improving the delivery reliability of major projects

3.1 Project Management in a historical context

It is first of all instructive to place project management (PM) in its historical context (Davies 2017); PM has its roots in OM: starting in the 1950s, basic tools including Critical Path Method/Analysis (CPM/CPA) were developed to improve project performance (Kelley 1963). This provided the basis for a toolset around which managers could begin to optimise complicated sequences of interdependent activities (Hartley and Wortham 1966). Further optimisations into PERT (programme evaluation and review technique) allowed the inclusion of probabilistic functions into the determinism of the basic approaches. The development of practice for many years focused on the OM maxim of *fixing the process* and it is notable how projects as a context for research, declined in their level of interest to OM academics. Project Management as a field of study, has *drifted away* from OM and OR (evidenced by the topic analysis by Walker et al. (2015)) and now takes on more from Organisation Studies and other disciplines. We interpret this as an intellectual separation of PM from its roots in OM/OR, a move which for both PM and

OSCM marks a critical omission. However, we are seeing a resurgence of interest (e.g. Browning 2010; Bendoly et al. 2014; Ramasesh and Browning 2014). Our initial observations demonstrated that many OSCM concepts (and related developments) are highly relevant to the project context.

Taking an OSCM view of major projects requires the consideration of both performance and improvement. This is of particular importance, as the success rate of major projects is generally low, and yet there are numerous bodies of what is locally considered to be *accepted best practice* (PRINCE2 2009; Snyder 2014). This discrepancy is our point of departure. We begin with no assumption other than this: that what is being applied generally now is delivering less than what is required nationally for governments, organisationally and individually for those charged with project delivery. Alternative approaches therefore should be considered, and an integrative adaptation of what has been proven to be successful elsewhere constitutes a reasonable assumption. This is our purpose here: to conceptualise such an integrative approach (Söderlund and Maylor 2012) we propose the concept of *lean leadership* – based on both lean thinking (Womack et al. 1990; Womack and Jones 1996) and project management philosophies, systems and tools. Early studies indicate that major projects can benefit from adopting such mainstream OSCM thinking (Maylor et al. 2015). While we focus on applying lean thinking to this new context, we acknowledge the potential that agile development (Fowler and Highsmith 2001), agile construction (Ballard 2008), the Theory of Constraints (TOC) (Goldratt 1990) and its application to projects (Goldratt 1997) could equally play such an integrative role. We will discuss their respective contributions below where we formally propose an alternative approach to managing major projects. In the following section we will outline how OSCM can help to consider the challenges of major projects differently.

In the context of OSCM, major projects provide a fascinating and relatively untapped context. Here, three characteristics in particular are germane to our analysis: (1) major projects are *unique* (i.e. they do not repeat), (2) they are enacted within the context of a *temporary organisation* (i.e. exists solely for the purpose of delivering the project), and (3) they are *complex* to manage (whereby complexity emanates from structural, socio-political and emerging issues). We use the term *project* in its widest sense here, encompassing *projects*, (major) *programmes* and *portfolios* (termed *P3*), and the concerns at an organisational level for the delivery of strategy through projects. There is no universal agreement on the definitions of these terms and whilst there are standards, e.g. (ISO21500 2012) and Bodies of Knowledge e.g. (APM 2012; Snyder 2014) the use of these terms in practice is often confused. For the purpose of this paper we define a *major project* as:

‘a set of interrelated operations uniquely and temporarily established to achieve a significant purpose and on a significant scale.’

In doing so we adopt the commonly accepted notion that projects have uniqueness at one level present in all the standards and conceptualise them as *temporary operations*. This follows the theorization of Lundin and Söderholm (1995), who framed projects as temporary organisations. This presents us with the opportunity to use the entire OSCM canon, but mindful that major projects are a special case where their characteristics – uniqueness, temporariness and complexity to manage – can be considered for their potential impact on the applicability of their approaches. This definition broadly agrees with the widely-used definition of major projects by Morris and Hough (1987) but explicitly incorporates the dimension of temporality.

3.2 An OSCM lens on major projects

We adopt an OSCM lens, based on the examination of systems of inputs, processes and outputs (Holweg et al. 2018). This lens allows us to do three things: (1) to separate the process from the output, (2) to measure the process output, and (3) to ‘open the black box’ of major project processes and apply OSCM concepts to this context.

The separation of process from output allows the consideration of how managers can organise resources for delivery of the outputs. This is done, for instance by considering the output as component, product or array (e.g. Shenhar 2001; Baldwin and Sauser 2009). This is helpful as it determines, for instance the role that an *integrator* will need to take at each level of the breakdown of the product (Davies 2004). Our focus for the purpose of this analysis is the process undertaken – on the active work done. When the ‘black box’ of the major project is opened, we see that there is no single process, but multiple nested processes. Indeed, there are multiple levels that can usefully be considered, which provide for a more nuanced description of process in this context. This could include the work carried out by individuals, teams, in a sub-project, the organisation, or even at a wider societal level (following, for example, Maylor and Blackmon 2005; Geraldi and Söderlund 2018). The relationships between projects and processes are well addressed in the first two papers of this special issue (see Artto and Turkulainen 2018; Harvey and Aubrey 2018).

In contextualising OSCM for use in major projects, we extend the prevailing notion of *outputs* to *outcomes*. Outputs in manufacturing, traditional project management and economic terms, are a product – a tangible artefact that is the result of a project. However, in many major

projects *outcomes* more closely resemble the results of service delivery and are less easily measurable. A project to deliver a new hospital, for instance will have products (physical infrastructure, machines, assets) as well as outcomes (new treatments, improved community health or potentially disenfranchised patients who are too far from the new facility). These outputs and outcomes typically yield a range of both financial and non-financial benefits. In economic terms, the *efficiency* of a major project is the ratio of output to input in purely financial terms, and this is a limitation of an exclusively economic perspective on performance. We note from OSCM (specifically service operations) that we can consider the *effectiveness* of the process as it relates to the customer's value perceptions and also need to therefore include outcomes in this consideration.

We also note that the tradition in OSCM of continuous improvement concepts have followed a path of extending beyond the focal context (traditionally manufacturing), into the broader organisation (e.g. NPD, sales, back-office), and the upstream and downstream supply chain. Classic examples include lean and TOC. We follow this path by merging the 'conversion' aspect in major projects (those elements of project processes where lean production is directly applicable) with the wider organizational aspects of lean that are not functionally limited. Lean has branched out beyond its origins in the factory, into service and the public sector (see e.g. Hines et al. (2004)). Our notion of the application of OSCM thinking providing a basis for performance improvement is widely acknowledged within the field, but is worth surfacing here before considering whether the translation to a new context would be worthwhile. Specifically, the performance of repetitive operations since the publication of 'The Machine That Changed the World' {Womack, 1990 #1720} in many sectors (notably automotive, electronics, fast-moving consumer goods, and retail) has improved measurably; deliveries that were once regularly late are now JIT, annual cost-down has replaced assumed inflation and quality, once expressed as percentage defects, is now expressed in parts per million defective (see e.g. Holweg and Pil (2004)).

In contrast, project performance in the years 1996-2009 according to a study by the Standish Group (Standish Group 2016), has not improved. If we examine the project context for an explanation for this, we see that process improvement for instance, rather than being ubiquitous and continuous, is piecemeal and episodic. Typically, improvement is the purview of post project reviews, which seek to codify learning from completed projects, for future projects. Whilst learning can and should be an important aspect of projects, it must be noted that post-project reviews are very long-cycle learning. In one major UK government department, such *lessons*

learned reviews have even been re-badged *lessons identified reviews*; the department recognised that in their words: '*We don't learn*'. In this light, the enduring performance challenge of major projects appears hardly surprising, and a different mechanism for improvement is required.

In the OSCM context, process improvement routines or *bundles of practice* are the common mechanisms to improve productivity (Shah and Ward 2003; Peng et al. 2008). Below we review and summarise key transferrable insights that we are taking from this body of knowledge, to supplement the reliance on post project reviews.

3.3 Lean production and product development

In repetitive operations, step changes in performance were achieved by the generation and application the philosophy, systems and tools of lean. In this paper, we posit that this philosophy, systems and some of the tools of lean production, and OSCM more generally, can be applied to major projects when integrated with 'traditional' approaches. However, there seems to be a fundamental contradiction at the heart of this proposition: lean is a philosophy that is derived from a repetitive manufacturing context that seeks to eradicate undesired waste and variation from the process (Womack and Jones 1996; Holweg 2007). Major projects on the other hand feature unique processes, are temporary operations and present considerable complexities for their management, including the need to deal with scale, time pressure, politics and considerable uncertainty. Significant applications of lean in construction have been reported (e.g. Koskela 1992; Koskela et al. 2002; Khanzode et al. 2006; Ballard 2008; Gao and Low 2014), mostly focused on planning and execution at the task level. In particular, the 'Last Planner System' has demonstrated how wastes can be systematically eliminated during project execution (Ballard 2000; Ballard 2008).

Lean has been successfully adapted to new contexts, and applications to product development, services and healthcare have been demonstrated (see for example: Clark and Fujimoto 1991; Koskela 1992; Murman 2002; Swank 2003; Radnor et al. 2012). We therefore argue that while some tools used in 'lean' may not be appropriate for major projects, it is worth developing a more nuanced discussion of what could in principle contribute to our strategy of *predict and prevent*. Taking forward the lean principle of eliminating waste in all its forms, we note the inherent waste in major projects: common examples include insufficient definition of project outcomes that lead to defects and rework, interface losses due to poor coordination across functions and stakeholders, and a mismatch between process layouts and task that leads

to operational inefficiencies. Furthermore, we argue that while the overall project may be a *one-off*, there is considerable repetition within sub-processes where lean can be applied – as demonstrated by the construction applications, in particular.

Of particular relevance in this context is the application of Lean Thinking to new product development (Liker and Morgan 2006; Mascitelli 2007), which conceptually is the closest to major projects. Seminal research by Clark and Fujimoto (1991), later expanded by Cusumano and Nobeoka (1998), highlights how the application of lean principles can have a demonstrable positive effect on product development performance. Key tools and mechanisms, such as stage-gating, frontloading, set-based concurrent engineering and cross-functional teams have been highlighted in subsequent work (Clark and Fujimoto 1988; Clark and Fujimoto 1989; Ward et al. 1995; Sobek II et al. 1999; Thomke and Fujimoto 2000). Lean Product Development is effectively the application of lean to *n=1 processes* – yet within the context of a mature organisation that repeats the process across product generations. It is interesting to note the conceptual parallels with the *agile* movement, which we will turn to next.

3.4 Agile development and DevOps

Like lean, the ‘agile’ or ‘agility’ movement also has its origins in manufacturing, where it was positioned as a counterpart to the perceived ‘rigidities’ inherent in the lean production paradigm to prevent an adequate and timely response of manufacturing system to changes in demand (Kidd 1994; Inman et al. 2011). Later work sought to reconcile the two paradigms, arguing that their respective approaches are complementary (Mason-Jones et al. 2000; Towill and Christopher 2002). More relevant to the underlying context here is agile translation into the software development (Fowler and Highsmith 2001), and project management worlds (Thomke and Reinertsen 1998) more generally. Here agile is similarly based on a new paradigm that seeks to drastically cut development times by instigating daily coordination meetings (*scrums*), by segregating the project into smaller work packages that become the focal objective (*sprints*), and by using a pull logic (*kanbans*) (Fowler and Highsmith 2001).

It is interesting to note here that many of the agile concepts in project management mirror key concepts within the application of lean to product development, which has been widely studied (Clark and Fujimoto 1991; Ward et al. 1995; Sobek II et al. 1999; Thomke and Fujimoto 2000; Mascitelli 2007). For example, the organisation into cross-functional product development teams follow the same logic of scrums, as do the *obeya* war-room and *heavy-weight project manager* concepts that facilitate rapid escalation and resolution of emerging

problems. Equally, *front-loading* and set-based concurrent engineering effectively partition the work into smaller (at times parallel) subtasks that can be more easily completed and managed.

In a similar context, the notion of *Development Operations* or *Dev Ops* seeks to integrate the two worlds of software development, and software operations. It seeks to provide a fast, flexible development and provisioning of business processes. Both concepts emanate from an IT context, yet are finding increasing application in projects more generally. Despite their growing popularity, however, one must note that the terms *agile* and *DevOps* possess considerable ambiguity (Gruver and Mouser 2015; Jabbari et al. 2016). Many software development projects now are conducted using agile principles, where the end result cannot be determined in detail in advance, but will evolve in iterations of work between the developers and the users (Highsmith 2009). Agile construction has a similar philosophy which involves delaying decision points (*postponement* in OSCM terms) on key design decisions until an acceptable set of credible options for that decision have been explored. This is highly utilised during the design phase of major projects, but is more problematic once construction starts. It likewise attempts to involve users in design decisions. Its application in major projects is therefore well established, though critique of the approach is sparse (Dybå and Dingsøyr 2008). Agile, like lean, has a core philosophy (Fowler and Highsmith 2001) and principles, systems (e.g. work organised into sprints) and tools (e.g. scrum meetings, progress 'burn down' charts). Integration of these ideas will require that there is some distinction drawn between these different considerations and that this is made explicit.

3.5 Theory of Constraints and the Critical Chain

Related to lean and agile, the Theory of Constraints (TOC) is another approach to process improvement within the manufacturing context (Goldratt and Cox 1984; Goldratt 1990). TOC was extended into the management of projects with the publication of *Critical Chain* in 1997 (Goldratt 1997). We contend that this should be a part of an OSCM perspective on major projects, as this is focused on the flow of work through systems. For the project context there is some translation needed in TOC, not least because the flow of work will not be between fixed resources in a repetitive and defined pattern in any given time period. Instead, once any work package is completed, new tasks with new interactions will take over. The *constraint* therefore is continually moving, rather than being a specific bottleneck resource. In addition, whilst the logic and resource availability are two specific types of constraints in projects, one of the most interesting (and with potential for study as *behavioural operations*) is the rules or behaviours that

are demonstrated. For instance, where work packages as a matter of custom and practice (a *rule*) start on a Monday (typical in many parts of the construction sector), regardless of when the preceding task was completed, this effectively stops work from *flowing* for the intervening days.

3.6 Synthesis: From 'predict and provide' to 'predict and prevent'

What can we take from the above review of OSCM concepts? First and foremost, there is the fundamental notion of process improvement. Core to OSCM is the exploitation of process repetition to dynamically learn and improve the process's efficiency and effectiveness (Holweg et al. 2018). We argue that this very notion equally applies to major projects, in two ways: first by learning from repetition of certain activities within the context of a single (major project). This is a traditional and manufacturing-centric view of improving a repetitive process.

Second, there is a strong case for transferring the learning of one project to the next. This cross-project learning is a common theme in lean product development (Karlsson and Ahlström 1996; Liker and Morgan 2006; Mascitelli 2007), which seeks to develop organisational structures and routines to make successive product development activities more efficient.

More generally, the notions of waste and value also directly relate to the wider discussion of the *performance* of a project. As has been argued, for example, the value of a project could be defined as the ratio of its performance over its cost (Siyam et al. 2015). This definition mirrors the general notion of efficiency in OSCM, which is defined as the change in the ratio over outputs over inputs in relation to time, or a standard (Holweg et al. 2018). In either case the performance increases if non-value added tasks are reduced from the project and/or if the output improves in terms of providing better value to the customer (Browning 2003).

We can transfer this logic to the previous Figure 2 and illustrate the difference in logic: rather than predicting the likely cost and schedule overruns and adjusting budget and schedule upwards, one could use the very same data to identify those comparable projects that have performed well (shown in dark shading), to identify the best practices that have driven this performance, to codify these learning points, and to transfer them to the next comparable project. As demonstrated in lean product development research, the argument is that – although there will be idiosyncrasies in each project – there are generalizable differential practices that can be identified, codified and transferred across projects.

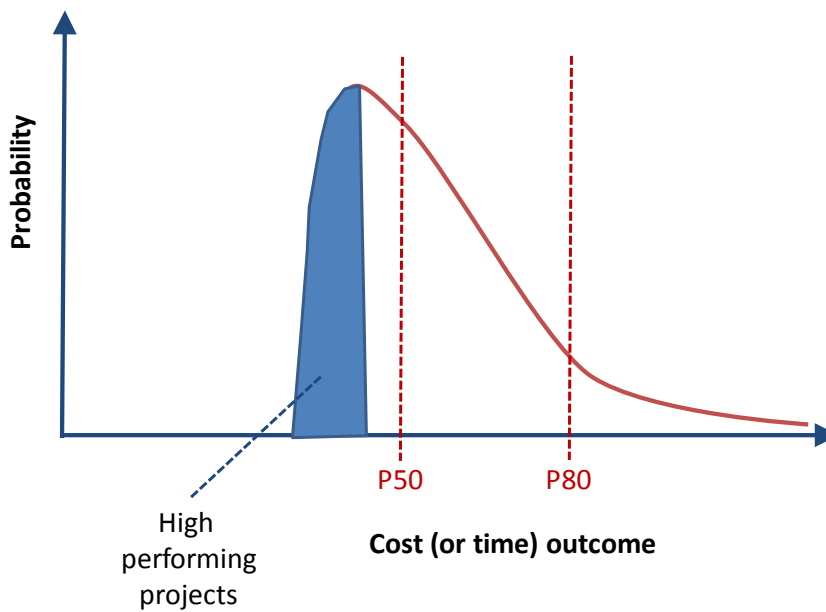


Figure 2: A ‘predict and prevent’ strategy, based on the logic of identifying, codifying and transferring best practices (shaded area) across similar major projects.

4 Universal Credit: An illustrative case study

4.1 Purpose and method

Case studies are widely used in OSCM research, and generally to develop and extend theory (Voss et al. 2002; Ketokivi and Choi 2014). In this study we use the case of the Universal Credit major project to explore the proposition that ‘old theory’ that is well-established in OSCM can be applied to a *new context*, namely the management of major projects. As such we do not seek to develop *new* (Eisenhardt 1989) or discuss *nascent* theory (Edmondson and McManus 2007), yet seek to explore the *contextual applicability* of established theory. As such we neither seek to develop new propositions for further testing nor are we testing prior propositions (Meredith 1998). We use the case to illustrate how lean concepts, in principle, can add value to the management of major projects. We neither can nor do claim general validity of our findings beyond the context of our case.

The case was purposively selected as its leadership has proactively engaged with the researchers in a variety of roles, yet with a common objective: to enable learning both from within and without the project. We present a longitudinal account of the Universal Credit major project from 2012-2016, which allows us to not only to observe a wide range of aspects of this project, but also to observe the changes in performance over time.

We draw on three distinct data sources, purposively mixing qualitative focus group and interview data with secondary quantitative accounts to minimise potential biases (Jick 1979): first, three formal workshops with the project leadership team were held with staff involved, in 2012, 2015 and 2016, to review performance and progress. The themes from the workshops and interfaces with delivery teams were recorded in personal research diaries. Second, we conducted frequent unstructured interviews with the current leadership (the project Senior Responsible Owner (SRO) and one programme director) of the project during the period 2015 to 2017. Third, we supplemented and triangulated our findings with third-party accounts that provided us with quantitative performance data. These included reports from the UK's Public Accounts Committee, the National Audit Office, and to a lesser extent informed journalistic sources (*Computer Weekly* and *The Times*). Finally, the written case account was checked by the SRO for accuracy.

4.2 Universal Credit: Overview and timeline

Announced in 2010 Universal Credit is a UK Government major policy initiative. It combines and simplifies six income-related benefits currently paid to 19 million people in the UK, in a digitised service. Amongst its objective are the reductions of costs and making working more attractive for benefit claimants. It integrates housing benefit (previously administrated and paid by 217 local authorities), income support and other benefits (administered by the UK's Department for Work and Pensions – DWP) and tax credits (previously administered by the UK's tax authority - Her Majesty's Revenue and Customs – HMRC).

The roots of the project are in late 2010. The then UK government published its White Paper (proposals for future changes to the law) outlining the agenda it wished to pursue by moving to a system of Universal Credit. This was followed in February of 2011 by the Welfare Reform Bill, a set of legislative changes that were eventually passed through both the House of Commons and the upper house, the House of Lords. The final part of the legislative process was completed in March 2012 when the bill received Royal Assent. The budget for the changes required to deliver Universal Credit was set at US\$2.6bn in 2011. Work was already progressing in 2012 on the project to deliver all the elements of the new system, and in April 2013, Universal Credit began taking claims for families in one region of the UK. February 2015 saw the national roll-out for single claims, and in May 2016, the service offering was expanded to the full Universal Credit.

The project has been notable for having no less than six SROs, the leader accountable to

parliament for its delivery, in less than five years. Two were removed from post, two were interims who stepped down after a short time, and one died. The SRO (whose tenure covers much of the period of this case) was appointed at the end of 2014 and was still in post late in 2017.

4.3 Project implementation

At the outset, the project was broken down, in traditional style, into a series of workstreams. Each was allocated to a major supplier who was responsible for integrating their work with that of other suppliers despite in effect competing with each other for work packages. A functional split between the suppliers was used; the bulk of the software was given to one firm, the hardware to another, the networks to another and the communications infrastructure to another. Traditional contracting rather than relational approaches were used, termed by one senior figure as *'like partnering, but with teeth'*.

In delivery, most workstreams used a traditional 'waterfall' approach for planning and executing work; work was broken down into logically dependent chunks and executed in a stepwise manner. For the development of the software that would run Universal Credit, the developer was using 'agile' development based on an iterative, rolling plan. The design for a particular piece of software was frozen for four to six weeks (a sprint), while the team carried out as much development as was possible 'burning down' the list of requirements in the process. At the end of each sprint, the objective was to have working code that could be tested and iterated with users. This was inconsistent both with the rest of the supply chain and with the contracts, which had set out the requirements at the outset (Computer Weekly 2013).

However, it was also ineffective, and in 2013 much of the code generated was deemed to be unsuitable and the contract stopped. US\$50M of software was written off. The contractors involved were notified of a 'significantly reduced involvement' for the remainder of the project. Since 2013, much of the development has been in-sourced, and iterations more closely tested with customers and in-house users. The delivery of new features is now significantly more reliable than previously.

There have been very high levels of rework and the project is running many years behind its original schedule, despite being a key policy objective for all governments during the case period. However, as does happen in major projects, there have been a series of resets, where the original goals are replaced by revised ones for the project.

As part of the governance of such large-spend projects, the project is scrutinised by multiple agencies and their reports determine whether the project continues to receive funding.

A notable success of the current SRO is his transformation of the relationship between the project and the various scrutinising agencies. Questioned over delays recently, his reply was interesting: *'The way I see it is like this. The original project requirements asked me to build a 3-bedroom house. We are now being asked to add two extra bedrooms. It is not the same thing at all.'* In performance terms, until 2015, the project had a rating of 'red' or 'amber red', indicating that peer reviewers deemed it at significant risk of not delivering. As soon as this level was triggered, the project was required to undergo enhanced reporting and scrutiny, consuming considerable time and resource of the leadership and the coordinating team. As of the end of 2016 it was rated as 'amber' demonstrating that there were still substantial risks, but that the confidence of delivery had improved.

Like all major projects, there is the potential for bad press. One benefit claimant being denied access to their benefits as a result of the new system could blow up into a major issue for the project team, regardless of the veracity or the claim, if picked up by the media. In the last half of 2016, the project was not hitting the front pages of the papers as it had over the past four years, but the widespread introduction of the system, has the potential for more bad press. This represents a continuous challenge for the leadership.

One of the foundations for the project was the continuity in ministerial policy provided by the Minister of State, Iain Duncan-Smith. Following a dispute with the Chancellor of the Exchequer, he resigned in early 2016. He was replaced by another supporter of Universal Credit, but he left the government in July 2016. The impact of ever-changing legislation was problematic too, for instance with the European Commission demanding that all EU citizens living in UK be entitled to UK benefits. Under considerable pressure from Euro-sceptics, the then Prime Minister waded into the argument, demanding an 'emergency brake' on EU migrants claiming benefits for four years. Such a requirement would have major operational challenges for DWP, not least in validating who had and had not been in the country for the necessary time. Contemporaneously, one of the key benefits being integrated into Universal Credit, child benefit, was changed. The entitlement to child benefit was limited to the first two children in a family. The politics of this project are never going to be simple and will require significant flexibility throughout the organisations involved, as an enduring feature of its context.

Such exogenous and endogenous uncertainties include both opportunities as well as downside risks. For instance, in upgrading data centres, there is the potential to rationalise and

modernise the provision of data storage, and for enhanced analysis of data. The opportunities are in addition to those already costed and the benefits claimed as part of the business case for the project. For instance, in 2012 there was little by way of established capability in the lead department to run such a project. Indeed, it had been in progress for several years before any real attention was given to its planning and then controlling progress according to those plans. There was little by way of basic PM skill evident in the department, with many support staff being temporarily drafted in to provide the capability. It was noted that due to staffing rotations prevalent in government at that time, as soon as any internal capability was developed, it was moved out of the project. In the long term, this may be of benefit to wider government, but in the short-term, it made providing any basic project management data problematic. Furthermore, integration between the individual workstreams was weak; it was neither incentivised through contracts nor 'owned' by any part with the necessary accountability and authority (over activities in the operations of the department or the project suppliers) to make it happen.

Building capability to design, develop and integrate systems and to manage such projects is a clear emergent benefit for the department, and one that did not form part of the original business case.

5 Discussion

Three themes emerge from the case study: First, using lean production as our point of reference, we observe a number of significant wastes arising from the organisation of the project in the way described above. Secondly, Universal Credit is a major project – a unique temporary and significant endeavour possessing considerable complexity to manage. There appears to be a logic to the process organisation, determined by the level in the task hierarchy (or Work Breakdown Structure) and the nature of the process being undertaken (the level of uncertainty that exists in the outcome required). We will explore this through the notion of levels within the project. Lastly, the role played by the leader is clearly significant (witness the turnaround in the performance of the project under the latest regime), and provides a feature of the context that is less emphasised in OSCM generally.

5.1 Wastes identified

Waste, in broadest sense, is any activity that absorbs resources but creates no value. The following wastes were evident in the case: First and most obviously, there were defects and

rework; writing off a large amount of software as '*not fit for purpose*' was a blow to the finances, progress and credibility of the project. This waste clearly translates well into the major project context. However, whilst this was avoidable, there were some wastes that it could be argued were less avoidable. For instance, progress had to be made on the project but changes in the law were inevitable. Therefore, there would always be some waste due to rework and this cannot be eliminated; the future state and interpretation of the law and regulation (as it evolves through purposeful change and case precedent) cannot be known in absolute detail in advance. It is an *emergent complexity* for the project (Maylor and Turner 2017). Ignoring the changes and continuing with building a system to an obsolete purpose would compound the waste. Therefore, the key issue here is about flexibility of response and resilience of the core or platform in tolerating inevitable changes. The first waste – avoidable defects and rework needs to be supplemented with a second – inflexibility in responding to emergence.

The third and fourth areas of waste came from the use of agile approaches and their incompatibility with the rest of the project. In some respects, the attempt to use agile should have been an appropriate response to the inevitable emergence in the project. Focusing on short sprints of activity in effect freezes the scope of the work to be done for a period of time, allowing progress to be made. The analogy with NPD is pertinent, where rapid prototyping reduces waste by increasing the speed and reducing the cost of iterations. In OSCM terms, this was an attempt to 'productionise' work (reduce the uncertainty and make it more like a repetitive production process) and reduce the level of uncertainty of demand during the sprint -- both are entirely consistent with lean thinking. However, it is not the individual work package organisation that was at fault, but the links between this and the rest of the project. The third waste then is inappropriate processing, and the fourth is losses at the interfaces.

The fifth waste represents a class of activity that is 'necessary but not value-adding.' We observed that much waste was created by 'assurance' of the project. For instance, wherever work was outsourced, there would need to be a team to check this both in the contractors and a system of technical authorities to approve content and changes, assigned by the client. This is in stark contrast to lean operations where dual checking by both providers and customers of products is highly unusual. Add in that as soon as the project showed signs of not delivering, all of the oversight bodies to which it reported diverted effort from the rescue to providing more frequent and in-depth reports. Attendance before parliamentary committees became a regular feature of the drumbeat of this project. This is the waste of over-checking.

The sixth waste is where learning in and from the project began to build delivery capability,

but this capability was then dispersed with the people who in effect ‘were’ the capability. In addition, the switch to greater insourcing demonstrated that the project learning was valuable and that this needed to be retained rather than allowed to leave with the contractors once tasks were complete. This waste in many ways is comparable to the eighth waste often added to Ohno’s original seven wastes: wastes skills and human talent.

The seventh and final waste is that of failing to take upside uncertainties. The principle that ‘if you don’t take your upside uncertainties, all of your uncertainties will be downsides’, is a behaviour that skews the performance of projects. For instance, at the interfaces between tasks, the project predominantly used fixed handover dates, despite inevitable task time variability. These dates were often missed, but importantly, there were key dependencies (e.g. the provision of the Real Time Information link from HMRC) that were delivered early. The challenge is then to take advantage of such an early finish. Unfortunately, because the subsequent tasks were not ready, the advantage was wasted.

We have identified a set of wastes within this particular major project delivery, some of which are specific to the project, while others match existing wastes in manufacturing and service. Table 1 summarises the wastes, firstly those common in the literature on manufacturing, then service operations, alongside those identified in the case.

Wastes in manufacturing operations	Wastes in service operations	Wastes identified in the case
Transportation	Unclear communication	Defects and rework
Inventory (excess)	Incorrect inventory	Inflexibility in responding to emergence
Motion	Unnecessary Movement	Lost capabilities
Waiting	Delay	Interface losses
Overproduction	An opportunity lost to retain or win customers	Over-checking
Overprocessing	Duplication	Inappropriate processing
Defects	Errors in the service transaction	Failure to capitalise on upside uncertainties
Skills	Service quality errors	

Table 1: Summary of Wastes in Manufacturing, Services and a Major Projects. Adapted from (Ohno 1988; Bicheno and Holweg 2016)

The commonalities in Table 1 include defects, errors in the service transaction and ‘defects and rework’ – similar across all three contexts. We note that there are important differences between manufacturing, service and the major project: for example idle capacity might be seen as a waste in manufacturing; however in major projects this capacity may be valuable as a buffer to ensure time-critical activities are not constrained by that resource. In low-volume aspects of the major projects we lack the consistent *flow* of repetitive tasks found in manufacturing, so here it would be inappropriate to always see idle capacity as waste. At the work package level (see next section) the manufacturing mindset is generally appropriate for repetitive tasks. However, a notable difference is where an upside uncertainty (e.g. work finishing early) cannot become a benefit to the project overall because a subsequent task is not able to start immediately. In a manufacturing process, a key objective is to minimise the chance that this could occur, by the continuous reduction of task variability. Reducing such task variability then is just one carry-over from repetitive operations to continuous improvement activities in projects.

5.2 A multi-level view of the project

There is a common argument used in major projects: the processes employed are unique, and therefore *optimization* or *process improvement* do not apply (an argument refuted in Harvey and Aubry, 2018 and Artto and Turkulainen 2018). Consistent with this, there is a tendency to treat all project activities as high-variety, low-volume. The case illustrates that such a representation is a gross oversimplification. The attempts to productionise software writing (albeit ineffectively) demonstrate the recognition that some of the work can be treated as repetitive. Indeed, whilst designation of the whole project as a unique process in the product-process matrix might be appropriate at that overall project level, once you drill down, the process characteristics will match a much greater range of process types.

For the purpose of discussing this case, we found it helpful to disentangle the various process types. Universal Credit has many levels of these. However, to make sense of it we recognise three key levels of operational systems, as shown in Table 2. This, we found, clarified discussions and enabled the application of appropriate levels of OSCM thinking. In addition, whilst we sought processes that deviated from the traditional arrangement around the diagonal

in the volume variety matrix, none that ‘worked’ were evident: this ‘old theory’ held despite some changes being required to the labelling.

Level	Description	Characteristics	UC Case examples
1	Major project – system of systems	<ul style="list-style-type: none"> ▪ Main governance layer, ▪ unique (n=1) 	<ul style="list-style-type: none"> ▪ Legislation change. ▪ ‘Once in a generation’ change to benefits and their administration.
2	Intermediate / systems	<ul style="list-style-type: none"> ▪ Mixture of activities, largely enabling work (design, legal, commercial) ▪ Batch processing 	<ul style="list-style-type: none"> ▪ Draft and gain approval for necessary legislation from policy to royal assent. ▪ Software (legacy systems, design, build test) ▪ Hardware (desktops, servers, networks). ▪ Staff and customers trained.
3	Operational / work package	<ul style="list-style-type: none"> ▪ Repetitive tasks 	<ul style="list-style-type: none"> ▪ Coding of individual software elements. ▪ Testing routines. ▪ Training events. ▪ Support provision in place.

Table 2: Operational systems levels within a major project

5.3 The importance of leadership

It is evident from the case that the role played by the project leader was crucial to the performance of the project. The early leaders struggled to make credible progress but when a new leader was appointed, they shaped the project differently such that progress could be made. Analysis of the changes made by the incumbent at the end of the case period demonstrated a number of elements of this leadership. The first was recognition of the wide range of choices available to them. In OSCM, we traditionally talk about process choices, and this, across the multiple levels of a major project, is a significant undertaking in itself. If we include the nature of the organisational design (e.g. Galbraith 1995) this expands beyond the traditional OSCM consideration of process, to include strategy, structure, people and rewards. The tensions in the rewards for the different suppliers would provide an entire paper for its analysis alone. If we add to this, the political nature of the project and how the broad body of stakeholders from government ministers to staff to benefit claimants needed to be incorporated into the process, there is clearly a second dimension to the task of the leader. It was notable that the incumbent was able to build relationships with senior stakeholders, and through these to exert influence that affected the environment in which the project was operating, in positive ways. In this regard, they were not only responding to traditional project structural complexities, but had effective

responses to socio-political and emergent complexities too (Maylor and Turner, 2017).

6 Lean leadership in major projects: An integrative framework

We have posited that ‘old’ OSCM theory, and lean thinking in particular, can inform the managerial challenges and choices of new contexts, and major projects in particular. The case has identified inherent wastes, the three levels of a major project, and the pivotal role played by the project leader. Our case clearly identified the potential for a *suitably modified version of lean* for major projects. We thus define lean leadership in major projects as:

‘the application of lean principles in order to identify, reduce and prevent wasteful activities in the design, delivery and realisation of benefits’.

Specifically, the lean philosophy provides the integrative framework including two key contributions to the management of major projects: (1) to understand value and define the purpose at the macro level of the major project, and (2), to act as integrator of best practices at the meso- and micro-levels of the projects. We will discuss each in turn.

6.1 Lean as conceptual lens to define purpose and value

A key purpose in lean leadership is to instil a *predict and prevent* strategy and mindset in the project. Past studies have shown the expected performance of the majority of major projects (Flyvbjerg et al. 2003; Davies et al. 2017), and we identified a legitimate response of increasing time and budget to increase the chances of project outturn predictability.

The alternative lean strategy we described as ‘predict and prevent’. In this we recognise that – if conventional practice is followed – then additional time and resource will be required in order ensure delivery predictability. The *prevent* part follows lean thinking in defining both purpose of the project, and the value from the stakeholders’ perspective. For instance, in the government project discussed but also in private sector examples, the addition of resources is contentious; it is seen as adding unnecessary *fat*. A lean approach seeks to identify practices associated with high performing projects and apply these to increase the chances of reduced time and cost of project completion. Analogous to repetitive operations, we need to break with the accepted approach of ‘predict and provide’ that in many ways help to propagate poor practices in major projects: as the saying goes, ‘if you do what you have always done, you will get what you always gotten.’

With purpose and value set, it is possible to configure the system at the meso- and micro levels for high performance. Specifically, lean can act as an integrator of practices associated with high performance, and use them toward fulfilling the purpose of the project.

6.2 Lean thinking as integrator of best practices

Lean leadership provides the mental model/framework for integrating Agile PM, Traditional PM, TOC and Lean tools into one coherent framework. This list is clearly non-exclusive, as future innovations are likely to be added to the toolbox. Our model for this integration, considered in the context of the 'levels' identified from the case is shown in Figure 3.

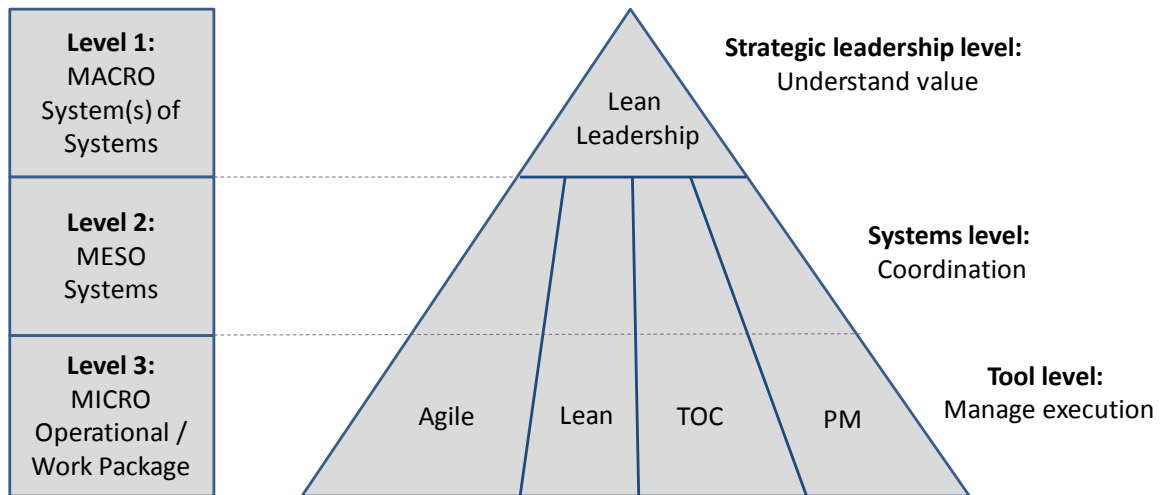


Figure 3: Lean leadership as integrative framework of best practices within the context of a major project

The core logic is that lean's focus on value sets the direction at the macro level, and ensures alignment of all activities at meso- and micro levels towards this objective. As agile, lean, TOC and traditional project management are all tried and tested tools, there is no need to discriminate against any one approach. In fact, quite the contrary: within the framework set at the macro level, lean leadership should seek to integrate all available tools to improve all aspects of major project delivery. This will, for example, include the application of lean production tools to repetitive tasks, the general project planning using traditional PM tools, and the selective use of agile sprints to complete certain tasks. All tools are used to play out their respective strengths, within the wider context set at the macro level.

7 Managerial implications: The principles of lean leadership in major projects

Major projects represent a particular challenge, yet to date we lack a coherent body of knowledge for leading major projects. Instead we rely on some normative work and idiosyncratic case studies. In many ways, major project leadership stands today where manufacturing was in the 1970s – there is a set of established practices, yet their respective shortcomings are both measurable and widely acknowledged. As we have argued in this paper, major projects (as a new context) can benefit from adopting established OSCM concepts, to go from a *predict and provide* approach to a *predict and prevent* strategy that seeks to develop a set of lean or best practices that can be transferred from project to project. We can summarise our findings into the following five principles for lean leadership in major projects:

1. **Set the vision.** We are not following accepted practice. Instead - at a macro level – our strategy encompasses *predict and prevent*, which is then deployed through meso- and micro levels of the project. In the Universal Credit case, this for example meant that they had to develop their own internal capability at agile software development. Because outsourcing – as accepted practice – did not work.
2. **Embrace emergence.** Unlike the context from which most OSCM concepts originate, where an existing system is improved from one repetition to another, in a project world there is, by default, a change in the nature of the task. This induces a paramount need to embrace emergence as it WILL happen. Emergence can be both exogenous and endogenous to the project. In the Universal Credit case this was, for example, an exogenous factor was the Prime Minister David Cameron's wish for a four-year limit before migrants can claim benefits. An endogenous factor was the fact that several features of new IT system were failing under test prior to launch.
3. **Eliminate waste.** Wastes are as prevalent in major projects as they are in any other process. As we have shown, they are of a different kind. We identified seven wastes within the context of our case: defects and rework, inflexibility in responding to emergence, lost capabilities, interface losses, over-checking, inappropriate processing, and a failure to capitalise on upside uncertainties.
4. **Create flow.** A key finding in our case is that – within a major project that seeks to produce a unique output or outcome – there are many highly repetitive tasks embedded at the micro level. These are prime candidates for lean improvements and

bottleneck analysis in order to create an improved flow of tasks, and in turn, reduce waste. An example in our case was an early delivery of a key component of the IT system, yet the project was not able to seamlessly continue the workflow.

5. **Improve continuously.** A core concept of lean thinking, and other improvement methodologies, is the need to continuously learn and adapt processes, systems and behaviours. As such it is of equal importance in a major project to identify the problems, escalate them quickly where needed, eradicate their root causes, and learn within and across projects. Universal Credit suffered from very poor performance at the outset, yet through codifying and transferring learnings, performance was improved considerably in later stages of the project.

In summary, major project delivery is a well-developed field of practice yet still a nascent field of scholarly study in OSCM. Our intention here is not to replace that which is known and valued in both practitioner and academic communities, but to demonstrate how it is 'necessary but not sufficient' for the delivery of major projects. If anything, our findings strongly suggest that major projects can derive significant value from adopting and adapting best practices from OSCM. Moreover, these would benefit from an enabling and integrative framework we have termed 'lean leadership.' This may also have a contribution to provide back into repetitive operations, where the traditional OSCM focus on structural complexities, becomes supplemented with considerations of responses to socio-political and emergent complexities.

8 Pedagogical implications

At present, OSCM and PM are often taught as two distinct fields. The former focuses on repetitive operations, the latter on the attributes and management of one-off temporary operations. Within the context of major projects, the opportunity presents itself for both fields being present in the one context. PM issues can be taught and considered at the $n=1$ level, with repetitive operations issues addressed at the work package level. With the right case study, this could cover both manufacturing and service contexts. This would allow students to consider established concepts including lean thinking, quality, capacity, scheduling, throughput, and their role in delivering both efficient and effective operations. Such a case could, for instance, be the development of a major piece of infrastructure. Within this, there are manufacturing operations (e.g. in provision of materials for construction), services (e.g. engineering consultancy, legal and

commercial services), complex supply chains (e.g. Aaltonen and Turkulainen 2018), in addition to significant logistical, strategic, ethical, sustainability and behavioural issues to be considered. These can be supplemented by the consideration of the operational transformation challenges that come with such an infrastructure project. As a case, this would be valuable to both practice and teaching not least by demonstrating the co-existence of a range of issues that the leaders of these temporary operations face, and where complexity can be reduced by well-recognised OSCM knowledge. Finally, such cases do demonstrate the considerable opportunity for the development of practices that begin to address the project performance paradox, whilst simultaneously enhancing OSCM knowledge.

References

- Aaltonen, K. and V. Turkulainen (2018). "Dynamics of organisational integration - the case of alliance projects." International Journal of Operations and Production Management(forthcoming).
- Ansar, A., B. Flyvbjerg, A. Budzier and D. Lunn (2014). "Should we build more large dams? The actual costs of hydropower megaproject development." Energy Policy **69**: 43-56.
- APM (2012). APM Body of Knowledge, 6th edition. A. f. P. Management. Princes Risborough.
- Artto, K. and V. Turkulainen (2018). "It takes two to tango: Product-organisation interdependence in managing major projects. ." International Journal of Operations and Production Management(forthcoming).
- Baldwin, W. C. and B. Sauser (2009). Modeling the characteristics of system of systems. System of Systems Engineering, 2009. SoSE 2009. IEEE International Conference on, IEEE.
- Ballard, G. (2008). "The lean project delivery system: An update." Lean Construction Journal **2008**: 1-19.
- Ballard, H. G. (2000). The last planner system of production control, University of Birmingham.
- Bendoly, E., M. Swink and W. P. Simpson (2014). "Prioritizing and monitoring concurrent project work: Effects on switching behavior." Production and Operations Management **23**(5): 847-860.
- Bicheno, J. and M. Holweg (2016). The Lean Toolbox: A Handbook for Lean Transformation, 5th edition. Buckingham, PICSIE Books.
- Browning, T. R. (2003). "On customer value and improvement in product development processes." Systems Engineering **6**(1): 49-61.
- Browning, T. R. (2010). "On the alignment of the purposes and views of process models in project management." Journal of Operations Management **28**(4): 316-332.
- Clark, K. B. and T. Fujimoto (1988). Overlapping problem solving in product development, Division of Research, Harvard Business School.
- Clark, K. B. and T. Fujimoto (1989). "Lead time in automobile product development explaining the Japanese advantage." Journal of Engineering and Technology Management **6**(1): 25-58.

- Clark, K. B. and T. Fujimoto (1991). Product development performance: Strategy, organization, and management in the world auto industry, Harvard Business Press.
- Computer Weekly (2013). Why agile development failed for Universal Credit. Computer Weekly, July 4th.
- Cusumano, M. and T. Nobeoka (1998). Thinking Beyond Lean. New York, Simon Schulster.
- Davies, A. (2004). "Moving base into high-value integrated solutions: a value stream approach." Industrial and Corporate Change **13**(5): 727-756.
- Davies, A. (2017). Projects: A Very Short Introduction, Oxford University Press.
- Davies, A., M. Dodgson, D. Gann and S. MacAulay (2017). "Five Rules for Managing Large, Complex Projects." MIT Sloan Management Review **59**(1): 73.
- Dybå, T. and T. Dingsøyr (2008). "Empirical studies of agile software development: A systematic review." Information and software technology **50**(9): 833-859.
- Edmondson, A. C. and S. E. McManus (2007). "Methodological fit in management field research." Academy of management review **32**(4): 1246-1264.
- Eisenhardt, K. M. (1989). "Building theories form case study research." Academy of Management Review **14**(4): 532-550.
- Flyvbjerg, B., N. Bruzelius and W. Rothengatter (2003). Megaprojects and risk: An anatomy of ambition, Cambridge University Press.
- Flyvbjerg, B. and A. Budzier (2011). "Why your IT project may be riskier than you think." Harvard Business Review **89**(9): 601-603.
- Fowler, M. and J. Highsmith (2001). "The agile manifesto." Software Development **9**(8): 28-35.
- Galbraith, J. R. (1995). Designing organizations: An executive briefing on strategy, structure, and process, Jossey-Bass.
- Gao, S. and S. P. Low (2014). Lean Construction Management, Springer.
- Geraldi, J., H. Maylor and T. Williams (2011). "Now, let's make it really complex (complicated)A systematic review of the complexities of projects." International Journal of Operations & Production Management **31**(9): 966-990.
- Geraldi, J. and J. Söderlund (2018). "Project studies: What it is, where it is going." International Journal of Project Management **36**(1): 55-70.
- Goldratt, E. (1990). The Theory of Constraints. New York, North River Press.
- Goldratt, E. and J. Cox (1984). The Goal. Great Barrington, The North River Press.
- Goldratt, E. M. (1997). Critical chain: A business novel, North River Press Great Barrington, MA.
- Gruver, G. and T. Mouser (2015). Leading the Transformation: Applying Agile and DevOps Principles at Scale, IT Revolution.
- Hartley, H. and A. Wortham (1966). "A statistical theory for PERT critical path analysis." Management Science **12**(10): B-469-B-481.
- Harvey, J. H. and M. Aubrey (2018). "Project and process: a convenient but simplistic dichotomy." International Journal of Operations and Production Management(forthcoming).
- Highsmith, J. (2009). Agile project management: creating innovative products, Pearson Education.

- Hines, P., M. Holweg and N. Rich (2004). "Learning to evolve - a review of contemporary lean thinking." International Journal of Operations & Production Management **24**(10): 994-1011.
- Holweg, M. (2007). "The genealogy of lean production." Journal of Operations Management **25**(2): 420-437.
- Holweg, M., J. Davies, A. De Meyer and R. Schmenner (2018). Process Theory: The Principles of Operations Management, Oxford University Press.
- Holweg, M. and F. K. Pil (2004). The Second Century: Reconnecting Customers and Value Chain through Build-to-Order. Cambridge, Massachusetts, The MIT Press.
- Inman, R. A., R. S. Sale, K. W. Green Jr and D. Whitten (2011). "Agile manufacturing: Relation to JIT, operational performance and firm performance." Journal of Operations Management **29**(4): 343-355.
- IPA (2016). Annual report on major projects for the Infrastructure and Projects Authority (IPA), reviewing its remit, portfolio and progress. I. a. P. Authority. London.
- ISO21500 (2012). Guidance on Project Management. I. S. Organisation. Geneva.
- Jabbari, R., N. bin Ali, K. Petersen and B. Tanveer (2016). What is DevOps?: A Systematic Mapping Study on Definitions and Practices. Proceedings of the Scientific Workshop Proceedings of XP2016, ACM.
- Jennings, W. (2012). "Why costs overrun: risk, optimism and uncertainty in budgeting for the London 2012 Olympic Games." Construction Management and Economics **30**(6): 455-462.
- Jick, T. (1979). "Mixing Qualitative and Quantitative Methods: Triangulation in Action." Administrative Science Quarterly(24th December): 602-611.
- Kahneman, D. and A. Tversky (1979). "Prospect Theory: An Analysis of Decision under Risk." Econometrica: Journal of the Econometric Society **47**(2): 263-292.
- Karlsson, C. and P. Ahlström (1996). "The difficult path to lean product development." Journal of Product Innovation Management **13**(4): 283-295.
- Kelley, J. E. (1963). "The critical-path method: Resources planning and scheduling." Industrial scheduling **13**: 347-365.
- Ketokivi, M. and T. Choi (2014). "Renaissance of case research as a scientific method." Journal of Operations Management **32**(5): 232-240.
- Khanzode, A., M. Fischer, D. Reed and G. Ballard (2006). "A guide to applying the principles of virtual design & construction (VDC) to the lean project delivery process." CIFE, Stanford University, Palo Alto, CA.
- Kidd, P. T. (1994). Agile Manufacturing: Forging New Frontiers. London, Addison-Wesley.
- Koskela, L. (1992). Application of the new production philosophy to construction, Stanford University Stanford, CA.
- Koskela, L., G. Howell, G. Ballard and I. Tommelein (2002). "The foundations of lean construction." Design and construction: Building in value: 211-226.
- Liker, J. and G. L. Convis (2011). The Toyota way to lean leadership: Achieving and sustaining excellence through leadership development, McGraw-Hill Education.
- Liker, J. K. and J. M. Morgan (2006). "The Toyota Way in Services: The Case of Lean Product

- Development." Academy of Management Perspectives **20**(2): 5-20.
- Lundin, R. A. and A. Söderholm (1995). "A theory of the temporary organization." Scandinavian Journal of management **11**(4): 437-455.
- Mascitelli, R. (2007). The lean product development guidebook: everything your design team needs to improve efficiency and slash time-to-market, Technology Perspectives.
- Mason-Jones, R., B. Naylor and D. R. Towill (2000). "Lean, agile or leagile? Matching your supply chain to the marketplace." International Journal of Production Research **38**(17): 4061-4070.
- Maylor, H. and K. Blackmon (2005). Researching business and management. Basingstoke: Palgrave MacMillan
- Maylor, H. and N. Turner (2017). "Understand, Reduce, Respond: Project complexity management theory and practice." International Journal of Operations and Production Management **2017**(In press).
- Maylor, H., N. Turner and R. Murray-Webster (2015). "'It worked for manufacturing...!': Operations strategy in project-based operations." International Journal of Project Management **33**(1): 103-115.
- Meredith, J. (1998). "Building operations management theory through case and field research." Journal of operations management **16**(4): 441-454.
- Morrow, E. W. (2011). Industrial megaprojects: concepts, strategies, and practices for success, Wiley Hoboken, NJ.
- Morris, P. W. and G. H. Hough (1987). "The anatomy of major projects: A study of the reality of project management."
- Murman, E. (2002). Lean enterprise value: Insights from MIT's lean aerospace initiative. Basingstoke, Palgrave Macmillan.
- NAO (2015). Major Projects Report. N. A. Office. London.
- Ohno, T. (1988). Toyota Production System: beyond large-scale production. New York, Productivity Press.
- Peng, D. X., R. G. Schroeder and R. Shah (2008). "Linking routines to operations capabilities: A new perspective." Journal of operations management **26**(6): 730-748.
- Pinto, J. K. and O. P. Kharbanda (1996). "How to fail in project management (without really trying)." Business Horizons **39**(4): 45-53.
- PRINCE2 (2009). Managing Successful Project with PRINCE2. T. S. Office. Norwich.
- Radnor, Z. J., M. Holweg and J. Waring (2012). "Lean in healthcare: The unfilled promise?" Social Science & Medicine **74**(3): 364-371.
- Ramasesh, R. V. and T. R. Browning (2014). "A conceptual framework for tackling knowable unknown unknowns in project management." Journal of Operations Management **32**(4): 190-204.
- Schoper, Y.-G., A. Wald, H. T. Ingason and T. V. Fridgeirsson (2018). "Projectification in Western economies: A comparative study of Germany, Norway and Iceland." International Journal of Project Management **36**(1): 71-82.
- Shah, R. and P. T. Ward (2003). "Lean manufacturing: context, practice bundles, and performance." Journal of Operations Management **21**(2): 129-149.

- Shenhar, A. J. (2001). "One size does not fit all projects: Exploring classical contingency domains." Management Science **47**(3): 394-414.
- Siyam, G. I., D. C. Wynn and P. J. Clarkson (2015). "Review of value and lean in complex product development." Systems Engineering **18**(2): 192-207.
- Snyder, C. S. (2014). A Guide to the Project Management Body of Knowledge: PMBOK (®) Guide, Project Management Institute.
- Sobek II, D. K., A. C. Ward and J. K. Liker (1999). "Toyota's principles of set-based concurrent engineering." Sloan Management Review **40**(2): 67-83.
- Söderlund, J. and H. Maylor (2012). "Project management scholarship: Relevance, impact and five integrative challenges for business and management schools." International Journal of Project Management **30**(6): 686-696.
- Standish Group. (2016). "The Chaos Reports, 1996 and 2009." from http://www.standishgroup.com/sample_research/index.php.
- Swank, C. K. (2003). "The lean service machine." Harvard Business Review **81**(10): 123-129.
- The Times (2016). Parliament Approves Replacing Trident. July 19. London.
- Thomke, S. and T. Fujimoto (2000). "The Effect of "Front-Loading" Problem-Solving on Product Development Performance." Journal of product innovation management **17**(2): 128-142.
- Thomke, S. and D. Reinertsen (1998). "Agile product development: Managing development flexibility in uncertain environments." California management review **41**(1): 8-30.
- Towill, D. R. and M. Christopher (2002). "The supply chain strategy conundrum: to be lean or agile or to be lean and agile?" International Journal of Logistics: Research and Applications **5**(3): 299-309.
- Voss, C., N. Tsikriktsis and M. Frohlich (2002). "Case research in operations management." International Journal of Operations & Production Management **22**(2): 195-219.
- Walker, H., D. Chicksand, Z. Radnor and G. Watson (2015). "Theoretical perspectives in operations management: an analysis of the literature." International Journal of Operations & Production Management **35**(8): 1182-1206.
- Ward, A., J. Liker, J. Cristiano and D. Sobek (1995). "The Second Toyota Paradox: How Delaying Decisions Can Make Better Cars Faster." Sloan Management Review **36**(3): 43 - 61.
- Wheelwright, S. C. and R. H. Hayes (1985). "Competing through manufacturing." Harvard Business Review **63**(1): 99-109.
- Williams, T. (2005). "Assessing and moving on from the dominant project management discourse in the light of project overruns." IEEE Transactions on engineering management **52**(4): 497-508.
- Womack, J. P. and D. T. Jones (1996). Lean Thinking: Banish Waste and Create Wealth for Your Corporation. New York, Simon & Schuster.
- Womack, J. P. and D. T. Jones (2005). Lean Solutions: How Companies and Customers Can Create Value and Wealth Together. London, Simon & Schuster.
- Womack, J. P., D. T. Jones and D. Roos (1990). The Machine That Changed the World: The Story of Lean Production. New York, Harper Collins.
- World Bank. (2016). "Gross fixed capital formation (current US\$)." from <http://data.worldbank.org/indicator/NE.GDI.FTOT.CD> - retrieved 10/2/2017.