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Megaprojects Redefined- Complexity Versus Cost- and Social Imperatives

Abstract:

Purpose

The purpose of this paper is to provide a brief overview from the literature on how best to define megaprojects in contemporary contexts. There is a need for a definition that encompasses a complex matrix of characteristics, inclusive of positive and negative aspects, which are not necessarily industry or sector specific. Whilst megaprojects have often been described and defined in terms of cost, they are more accurately delineated by their convolutions. Intricacies arise from political intrigues surrounding funding of such projects and managing and governing complex social and organisational relations. Points for future research are also identified, including: contexts; procurement; institutional perspectives; constituting megaproject cultures; and sustainability.

Design/methodology/approach

An analysis of international megaproject literature over the past five years combined with seminal works was undertaken. Drawing on the broad literature of project and program management combined with elements of organizational theory. Whilst some examples are cited, in depth case analysis has not been covered.

Findings

Albeit that the scale of some megaprojects is comparable to national GDP's, seven more characteristics beyond size have been identified which, distinguish megaprojects from large projects. These include: reach; duration; risks and uncertainties; widely disparate actors; areas of controversy such as dispute resolution; and legal and regulatory issues.

Originality/value

Rigorous stakeholder engagement is critical for success in megaprojects and collaborative learnings need to be exchanged. The longer term social and economic impacts need to be viewed as an imperative rather than a hindrance to the planning and execution of megaprojects and complexity rather than cost more aptly defines megaprojects.

Keywords Megaprojects, Complexity, Characteristics, Social, Economic, Innovation

Paper type Literature Review

Megaprojects are changing the face of Sydney, Australia. The Westconnex which entails thirty three kilometres of a new motorway scheme currently under construction, and Barangaroo a precinct redeveloped from shipping and stevedoring facilities to commercial and recreational spaces are just two of the most evident projects, because they are very advanced in their impact. It is in this context of the increasing importance of megaprojects to the local environs that it is timely to provide analysis of the main features that make up megaprojects, drawing on the broad literatures of project and program management and organisation theory.

1. Multifaceted aspects of defining Megaprojects

In the past, historical megaprojects have left many famous landmarks: the Pyramids, the Great Wall of China and so on. Since ancient times it seems that a number of civilizations have had a fascination with large-scale monuments, buildings, activities and events, usually as defensive or symbolic expressions of power and status. The appeal of megaprojects persists globally in current times with advocacy from both political and developer proponents

expressed for example through large-scale urban transformation projects and substantial financial expenditure.

Megaprojects have been broadly described as “large-scale, complex investments that typically cost a billion dollars and up, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people” (Flyvbjerg, 2014a). It is, however, not the cost but the complexity that marks out a megaproject. The intricacies arise from the politics associated with funding, managing and governing complex social and organisational relations. Involvement ranges from committed stakeholders amongst the contractors and civic authorities to those that are resistant, embedded in existing communities, social movements and advocacy organizations.

This paper aims to present a brief snap shot of what megaprojects mean in today’s terms. It outlines the common problems, key characteristics benefits that are intended as well as misgivings about the problems that such projects present, together with ideas around solutions for maximising benefits and minimising the more challenging issues.

Cost is often seen as the criteria for deeming something a megaproject. For instance, both the European Union (EU) and the International Project Management Association (IPMA2011) explain them in these terms. A megaproject is defined, across all industries, as one for which the benchmark, is that it costs more than ‘100 million euros’ (Hu et al, 2015). However, this is not really satisfactory: a 100 million Euros spent on a project in a deserted territory or one that suffers under highly authoritarian rule is hardly the same as one conducted in a democracy in which there are active citizens. The classification of megaprojects needs to be more nuanced, taking into account the trajectory of the term in academic and practitioner publications.

Navigating the way the term is positioned across publications such as Flyvbjerg’s (2014a) *Megaproject planning and management: Essential readings* and *The Oxford Handbook of Megaproject Management* suggests a number of critical and persistent themes. First, there is significant continuity between the management of megaprojects and large-scale project management. The broad historical contexts for the initial notion of megaprojects are discernible within the discipline of project management. These are centred on the way the project manager’s role has changed to take into account projects embedded in “advanced technology industry”, involving larger and more complex projects and tasks. Project Management has emerged as a profession characterized by particular sets of skills and technical expertise (Gaddis, 1959 in Flyvbjerg, 2014a), applied to large-scale projects. What might simply be a large-scale project in one context of relatively simple political and organizational relations could be considered a megaproject in another situation that posed far more in the way of complexity to be managed.

Megaprojects need to be approached through more than their scale even though the scale of some megaprojects is comparable to national GDP’s. The inherent intricacies also require consideration (Ansar et al, 2016) “Bigness entails multiple problems and unpredictable interactions across dimensions” – problems and intractability linked to economies of scale and “investment fragility” (Ansar et al, 2016). However, there is more to a megaproject than simply size and finance.

Based on a review of prominent literature characterising megaprojects (Biesenthal et al. 2017) identify seven more characteristics that make them different from complex or large

projects: reach; duration; risks and uncertainties; widely disparate actors; arenas of controversy; legal and regulatory issues. They suggest that what differentiates megaprojects is their reach and the broad impact they have on society and the environment.

Megaprojects have often been studied within a sector or industry; however, increasingly they are not industry or sector specific but extend across an institutional field. An institutional field may be defined as comprised of those “sets of organizations that, in the aggregate, constitute a recognized area of institutional life; key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products” (DiMaggio and Powell, 1983: 148). Actors and organizations within an industry will constitute such a field “whose participants interact more frequently and fatefully with one another than with actors outside of the field” (see Scott, 1994: 207-208). The complexity of the megaproject field is generated by the fact that this frequent and fateful interaction, contra other elements of Scott’s definition (he stresses the importance of a ‘common meaning system’), is frequently a contested terrain. The larger the project, the more complex the institutional field, and the more frequent and fateful the interaction, then the more contested and complex one would anticipate the project to be. A megaproject is not only big, in terms of scope and scale and costs – it is also big in its potential for politics in and around the project.

The institutional fields in which megaprojects most frequently cluster centre on the following:

Goods and services across a range of businesses and sectors:

- Infrastructure, water and energy, information technology
- Industrial processing plants, mining, supply chains, enterprise systems, government administrative systems, defence, Intelligence, air and space exploration, urban regeneration, and major events.

Mega change management

- Strategic corporate initiatives and change programs, mergers and acquisitions, banking, big science
- National Health Care Systems

Examples of megaprojects:

- High-speed rail lines, airports, seaports, motorways, hospitals, national health or pension ICT systems, national broadband, the Olympics, large-scale signature architecture, dams,
- Wind farms, offshore oil and gas extraction, aluminium smelters, the development of new aircrafts, the largest container and cruise ships, high-energy particle accelerators, and the logistics systems used to run large supply-chain-based companies like Amazon and Maersk

Each of the institutional fields constituted by projects in these areas will differ, with different stakeholders, relevancies, and problems. Megaprojects, as a generic concept for useful research may not be appropriate across all fields i.e. No one size fits all. Each constitution of

an institutional field has specific issues and these emerge from contextualised problem situations across different phases and cycles of the design, planning and implementation phases. At times when solutions or explanations surrounding a megaproject are sought these are necessarily mixed. There is need for a definition of megaproject that encompasses a complex matrix of characteristics, positives and negatives, as well as linked features and aspects of specific sectors/industries. Also, there is a need to produce a similar template for a focus on different disciplines and approaches in an academic and practitioner sense.

Making sense of megaprojects

Megaprojects have been seen through a power and sensemaking lens (Flyvbjerg 1998; Clegg et al, 2017) that sharpens the focus on a number of elements. These include the ways in which contractual relations shape the ‘norms of competitive contracting’, facilitating quite specific project power relations, often expressed in terms of the drive to ensure contractual expectations of profit and meeting of schedules, as well as cost control, leading to cost cutting. On these criteria, megaprojects are notoriously unsuccessful: they routinely do not come in on time, on budget, on specifications or predictions as to their value. The narratives representing megaprojects are telling in their metaphors: perhaps the most pervasive is that of ‘escalation’ – of commitment, of costs, of complexity, of conflict. If narrative is critical to the ways in which megaprojects are perceived, such that the coherence of their storyline is important in framing a semblance of success (Low and Sturup 2014), assisting in the determination of which projects are deemed to be a triumph, there are very few success stories. Much more common are metaphors that see unsuccessful megaprojects as the norm, representing some kind of uncontrollable species. “Megaprojects are a completely different breed of project in terms of their level of aspiration, lead times, complexity, and stakeholder involvement. Consequently, they are also a very different type of project to manage” (Flyvbjerg, 2014b). Megaprojects have also been described as the “wild beast” of the project world (Zidane et al, 2013) and likened to unruly trolls – difficult to tame and control (Klakegg, et al 2016).

One of the reasons that megaprojects are regarded in such metaphorically grim terms may well be the provenance of project management discourse and its relative autonomy from more established areas of organization theory, well versed in uncertainty, complexity and conflict and their management. Boiled down to its essentials Flyvbjerg et al’s (2003) influential work suggests two propositions: first, that megaprojects will routinely exceed estimates of their risk in terms of costs, completion, and other performance indicators. Second, they will regularly exceed estimates of their risk in terms of costs, completion and other performance indicators because those associated with their commissioning and implementation will use deceptive indicators and misleading projections resulting in the misallocation of scarce resources (Flyvbjerg et al 2003: 20).

While the first proposition is undeniable it does not follow that the second proposition is true. If it were, the institutional field that constitutes megaprojects would be populated by participants who are incapable of learning from experience that the rules they are applying will not produce the predicted results. This would imply that no institutional learning takes place in the management of government, public sector bureaucracies, banks and share portfolios. The assumption being made seems to be that large-scale organization is normally characterized by rationality and that any deviation from the rational norm must be aberrant. We think that there must be a better explanation for the dismal outcomes that Flyvbjerg et al (2003) have identified, if only because we are neither convinced by the normalcy ascribed to

rationality per se nor are we inclined to believe in widespread conspiracies against the public interest.

First, let us consider the general critique of rationality. It is a foundation stone of modern management, that it is premised on rationality. Rationality flows from headquarters, through heads of departments, into action, via rational decision-making. Problems are defined; all the relevant information that leads to an optimal solution is collected; experts work on that information to create plans; these plans are carefully evaluated, and an optimal solution decided; then, knowing what is to be done, implementation follows with constant evaluation to correct any deviant loops away from the plan. Modern project management holds these truths to be infallible. Modern organization theory is less sanguine.

March and Simon (1958) express doubt that decision makers really do look for optimal solutions. They suggest that they cannot because they never have sufficient information to be able to do so. Instead, they look to “satisfice”, a new word coined to suggest that they aim to create the most satisfactory outcomes that they can, given what they know, are able to access, and process. People generally have bounded rationality; they operate with limited search, imperfect knowledge, and finite time. Megaproject sponsors, financiers and managers are no different; they too work within the bounds of their own rationality. Hence, they are not so much operating according to the norms of economic rationality – having perfect knowledge contained in an unambiguous price signal about the choice of substantively similar perfectly competitive goods – as operating under the stresses of the situation, processing what is at hand and what they know, to try and work out what they will do. Pushing the logic of this scenario a little bit further Cohen, March and Olsen (1972) suggest that the logic of organizing in complex organizational situations is akin to the logic of what they call the garbage can. Decisions are made when solutions, problems, participants, and choices flow around and coincide at a certain point. The adjacencies, much as garbage in a trashcan, are often purely random. Or as Starbuck (1983) suggested, organizations are not so much problem solvers as action generators, generating problems to which they already have the solutions.

Now if these traits characterize organizations they will be much more characteristic of projects. Here there is usually no singular centre of calculation and control but many collaborators; each project, by definition, is unique, and requires unique learning and transfer of knowledge; projects are characterized by an identity that is ambiguous, has fuzzy limits, and a duality between objects and actors who are willing them into being (Engwall 1998). Projects are complex: they are not marked by routine repetition of short time cycles. They involve multiple competencies, each of which will be characterized by its specific rationalities, a la the garbage can model, such that talk, decisions and actions will not necessarily be aligned with each other.

Thinking of how megaprojects become funded, one can suggest that launching megaprojects and keeping them going presents ample opportunity for what Brunsson (1992) calls the organization of hypocrisy to occur. Hypocrisy is generally be thought of as a form of insincerity where one acts as if one had qualities or convictions that one does not really have; nonetheless, megaprojects would never occur without substantial amounts of falseness. If government and finance demand risk analysis and hard figures for project proposals then the job of project brokers and managers is to try and produce them, even if they know that the figures they are dealing with are highly imprecise and speculative. Otherwise, no project

would ever get talked into being. Facing a demand for certainty while confronting much that is unknowable and undecidable may well make hypocrisy the norm.

In addition, there are inherent features of project management and organization, once it has been talked into being, which will tend to produce further hypocrisies. In the context of the construction industry, the contract and its associated documents are the central framework shaping managerial discourse. Most contracts are of the kind that is referred to as hard money contract – where the construction being undertaken is bid for on the basis of the specifications in the contract, for a definite price, and where the most competitive tender wins the contract. What this does is to set up a constitutive framework in which the meaning of the contract plays an essential role. Despite recommendations to the contrary in the procedural handbooks of the industry, contracts are never unequivocal; they are highly indexical and whoever is interpreting them is likely to do so from a position that indexes a specific set of interest: that is, contracts cannot be read simply as a precise and unequivocal set of instructions for delivering a projected outcome. There are at least two reasons for this, we argue. Both are questions of context – one immanently material to the conditions in which the specific contract is enacted and the other transcendently constitutive of all contracts.

The immanent reasons are simple. Contractual specifications, typically, are large and complex bodies of documentation: not only are there the documents on which the work is bid but there are also detailed consultants' reports and associated documents. In an ideal world these would exist in an absolute and seamless correspondence of all detail from one document to another such that no document ever contradicted another or was in conflict with it. Given the vast amount of paper – comprising detailed specifications, reports, and projections – associated with complex projects, many hands, at many times, deploying many distinct skills, produce these texts. More often than not there will be points of ambiguity or even disagreement between them. Project personnel will be more or less skilled game-players, displaying a mastery of occupational and organizational rhetoric that enable them to make something out of the opportunities presented. Potentially the greater the complexity, the greater there is opportunity.

What makes the organization of hypocrisy unique in the world of megaprojects is the time-lagged nature of these phenomena. While most people may expect a rational model of organizations, with consistency between talk, decisions and action, in megaprojects the time lapses between the talk (and other forms of discourse such as the project brief and other documents), the incremental and interlinked nature of the decisions, and the delayed action in terms of final project outcomes means that the organization of hypocrisy should be the expected norm.

2. Trajectory of megaprojects in the literature

Academic landscape

Complications aplenty attach to developing an academic focus on megaprojects. What one should expect are recommendations for limiting opportunities for organizational hypocrisy. A

review of various literatures suggests areas in which this might be done. In terms of academic papers found on Business Source Complete¹, the following subject terms emerged:

Project Management	Cost control
Infrastructure (economics)	Management
Construction Project Management	Strategic planning
Economic development	Urban growth
Construction industry	Urban planning

The broad academic focus of work on megaprojects demonstrates varied ways of exploring the topic, including accounts from urban planning as well as more technically focussed areas such as Construction Engineering and Management (CEM) and Project Management. Research emerges as a specific area of interest.

Practitioner landscape

The practitioner landscape² produces only a slightly different focus. The overlap in subject focus (same BSC search) was very similar but there were a couple of critical differences highlighting the shift of focus to more finance and trade related areas (Highlighted in bold):

Construction Industry	Economic Development
Infrastructure (Economics)	Investments
Project Management	Conferences & Conventions
Construction Contracts	Contracts
Petroleum Industry	Finance
Railroads	Economic Development

White Paper/Policy Reviews

In essence, the policy reviews outlined a number of pragmatic solutions in handling megaprojects on a wider societal level. These papers take into account the economics and relationships of diverse stakeholders.

LSE Growth Commission report

In 2013, LSE Growth Commission published a report on economic growth in the UK for the next 50 years. This report explored institutions and policies inherently connected to the impetus for growth. Besley et al (2013) developed a paper summarising the findings of the

¹ The following publishers of academic peer reviewed articles on megaprojects frequently arose: Elsevier Science; AACE International; Taylor & Francis Ltd; American Society of Civil Engineers; Project Management Institute; Finance & Credit; Sage Publications Inc; *University of Technology Sydney*; Sage Publications, Ltd; Emerald Group Publishing Limited.

² Amongst the publishers for practitioner/trade related articles the following names arose, showing a marked difference to the academic list of publishers: Meed Media FZ LL; BNP Media; Project Management Institute; Pennwell Corporation; Sourcedmedia, Inc.; DVV Media UK Ltd.; Faversham House Ltd.; INS Communications Pte Ltd; Oildom Publishing Company of Texas, Inc. and CPA Australia.

report in *Investing for prosperity: skills, infrastructure and innovation*, highlighting three core areas of focus – human capital, infrastructure and technology. The report outlined that the key area of long term and well considered provision of infrastructure was inherently connected to economic growth best seen as a nodule in a suite of reforms and changes. Considering large infrastructure as a form of megaproject invariably links it to the economic outlook of a nation. As such megaprojects are seen as an active component of the economy conceived in a systemic manner.

The Commission proposed a number of new institutions and processes to deal with issues around poorly managed national infrastructure development and economic growth. This included an Infrastructure Strategy Board (ISB) to play a role in providing expert independent advice and an Infrastructure Planning Commission (IPC) to deliver on the ISB’s strategic priorities. A number of events took place subsequent to the 2013 report, with the National Infrastructure Commission being set up (on an interim basis on 5 October 2015) to examine the future of the UK’s needs for ‘nationally significant infrastructure’. Doing so was seen as integral to assist in maintaining UK competitiveness amongst G20 nations. The other aim included was to provide greater stability for investors by focusing on ‘long term’ approaches for national investment decisions.

The findings of the LSE report are applicable to the Australian context where we also see a lag in productivity and a need for public service innovation, smarter ways of investing and carrying out large projects.

Roads to Riches

Exploring white papers and policy reports relevant to the Australian context one sees similar themes emerging about a need for better regulation around large transport infrastructure projects. The Grattan Institute Report, “Road to Riches: better transport investment”, discusses how government spending on transport infrastructure in the last ten years has been unprecedented and at the same time poorly considered. Although the Mining Boom and GFC influenced government spending and stimulus, it has been argued that large sums of money were used in misaligned projects and that activities were influenced more by a political agenda than community needs (Terrill et al, 2016). We should expect that this would be the cases: in the absence of any controls on hypocrisy we would expect political self-interest to be paramount in determining funding priorities. Cities are the “engines of national economic growth” (Terrill et al, 2016:2). Cities in Australia face increasing populations, congestion and competition yet spending on major projects within them is determined by political agendas and vote-seeking by politicians. This has shaped investment spending, resulting in it being poorly designed and executed.

The establishment of Infrastructure Australia is aimed at improving spending on infrastructure but much more could be done to strengthen the institutional forces at play. A rationale, which includes a transparent process, is needed to ensure that projects are well-argued with realistic parameters in their proposals. The Grattan Institute report outlines three recommendations to address problems around transport infrastructure projects:

- Government should not commit to transport infrastructure projects before an evaluation takes place by an independent body and a business case is developed. These need to be tabled in Parliament. This has not been the case with major recent megaprojects such as WestConnex.

- Once tabled in Parliament, the projects need to be progressed to completion. Where the community benefits outweigh the cost, this determines the need for all such projects to be built and these projects should be prioritized for government spending. These criteria of public value have not been spelled out clearly.
- Commonwealth funding needs to be considered as separate from GST entitlements, with a focus on the national economy, regardless of which state the project is located within. (Terrill et al, 2016)

MGI reports

According to the McKinsey Global Institute Report (MGI, 2016) on Bridging Global Infrastructure Gaps \$2.5 trillion is invested globally in infrastructure such as transport, water, communication/telecom systems. This amount is not adequate, the report suggests, when taking into account the increasing needs of businesses and the population depending on such infrastructure.

The report estimates that global infrastructure investment from 2016-2030 needs to be approximately \$3.3 trillion a year just to meet expected rates of growth. MGI forewarns that if the current underinvestment continues, the global shortfall will be \$350 billion per year, possibly triple this amount if the UN Sustainable Development Goals are taken into account. This estimation also envisages lower economic growth and lack of services as needed for the populations, both business and domestic, short of such investment. The MGI Report highlights the more complex aspects of megaprojects and their place in global economics.

The report builds on a 2013 report (MGI Report, 2013) and updates estimates of the world's infrastructure needs and how these are not being fully met. As such the report makes recommendations for addressing global infrastructure gaps.

The MGI 2016 Report also outlines a series of changes required:

- An increased need of public infrastructure investment with the government playing a significant role by increasing funding streams. User charges, capturing property value, selling existing assets and using proceeds for new infrastructure are all recommended (MGI, 2016).
- Changes to financial frameworks are recommended with the suggestion that public accounting standards be aligned with corporate accounting whereby infrastructure assets depreciate over a life cycle as opposed to adding to deficits during construction, reducing 'pro-cyclical investment behaviour' (MGI, 2016).
- Tapping into investment in privatized sector would need regulatory certainty with acceptable risk adjusted returns and other processes, such as land access, permits and approvals.
- Public Private Partnerships (PPP) are important in infrastructure projects – the report indicates that there is a question as to whether PPPs deliver on efficiency and lower costs. Still, they play a role as a source of future financing and account for 5-10% of total investment. The Report highlights that public and corporate investment is a more significant issue (MGI, 2016).
- \$120 trillion in assets are tied up in banks and institutional investors – these could support projects in infrastructure. The vast majority, i.e. 87% of these funds, come from advanced economies while the greatest need is in middle-income economies. The report highlights that cross border investment principles will be required to match

investors with projects. A number of issues need to be addressed such as: regulatory rulings on investment on infrastructure assets; absence of an efficient market, and most importantly, improving the pipeline of profitable projects. (MGI, 2016)

- Accelerating productivity growth in the Construction Industry: the MGI 2013 report demonstrated that improving on a number of areas such as “project selection, delivery, and management of existing assets” could amount to 40% savings (MGI, 2016: viii). In the 2016 report, MGI completed comprehensive diagnostics measuring the efficiency of infrastructure systems in 12 countries. It identified the need for improvement in most economies, including the advanced ones, with scope to “build stronger capabilities with learning institutions with strong oversight” (MGI, 2016: viii)

The report also outlined a need for rigorous assessment benchmarking aspects of infrastructure development and the development of global best practices assisting in compiling and identifying areas to yield best-targeted results.

3. Characteristics

Key variables

Clearly, in conceptualizing what are the significant variables in managing megaprojects we need to include at least the following parameters.

- Size: this could include the size of the project or the size of the impact.
- Cost: a specific value included in many technical definitions. Flyvbjerg links cost to a number of levels (see Table 1)
- Uniqueness: megaprojects by their very nature include some overt factor that could be deemed unique.
- Schedule: a schedule tied to contractual milestones and project management, an inherent timeline for the project completion is usually indicated as a part of the megaproject process.
- Scope: a comprehensive sense of what the whole project includes in terms of time, content and delivery
- Governance: a clear line of governance and delineation of process and power of decision making is the engine room of the megaproject
- Stakeholders: there are complex relationship, including inter and intra relationship pertaining to stakeholder interest in the megaproject. These include social, financial, environmental, community and other more implicit and hidden stakeholders.
- Complexity: this is also an inherent aspect of the megaproject which includes multiple levels within all the stated characteristics and how these influence each other positively or negatively
- Risk: is often conflated with complexity and decision-making but is a characteristic that drives the finer and more volatile aspects of the megaproject.
- Optimising Value – from a social and economic point of view

In terms of scale, Flyvbjerg explored a number of terms used to describe megaprojects and the timescale in which these emerged; however, despite the emergence of these other terms, the main terminology evident in the literature persists as “megaproject”, dating from the 1850s.

Prefix	10 ⁿ	Scale	Project type	First heard
Mega	10 ⁶	1 million	Megaproject	1850s
Giga	10 ⁹	1 billion	Gigaproject	1960s
Tera	10 ¹²	1 trillion	Teraproject	2000s
Peta	10 ¹⁵	1 quadrillion	Petaproject	?

Table 1: Project size in US\$ (Flyvbjerg, 2014a: xv)

Overall, these discriminant terms are not particularly conceptually useful. The reasons are as stated previously: cost does not solely a megaproject make. We need to factor in the full range of variables.

Disciplining megaprojects

Disciplines relevant to Megaprojects include:

- Engineering
- Architecture
- Environmental Planning
- Science
- Business
- Organization and Management Theory
- Project Management
- Urban Planning

Another set of categories emerged through citation analysis, (in the next section) in terms of top research areas. While not an exhaustive list these included.

- Business Economics
- Environmental Sciences Ecology
- Geography
- Public Administration
- Engineering
- Urban Studies
- Government Law
- Social Sciences other topics
- Construction Building Technology
- Energy Fuels

In terms of approaches the following are some of the organizing categories in general use.

Historical perspectives:

In exploring historical aspects of megaprojects, such as post WWII projects, the practices of project management and its technical systems are highlighted. The changes over time emphasise the emergence of relevant and effective practices, some of which are held as possible systems for current megaprojects (Lenfle & Loch2017). These authors suggest that a possible return to previous project management systems and practices that have been deemed effective could be drawn on for new methods for dealing with current dilemmas in

megaprojects, especially around core areas such as uncertainty, contractual aspects and stakeholder interests.

Events: Olympics:

Mega events, such as the Olympics, have been deemed to be megaprojects. A number of urban developmental modes have been attributed to the building and development for Olympics. The large scale ‘spectacle’ of opening ceremonies (Broudehoux, 2010; Tien, Lo, & Ze, 2011; Müller, 2011) are often seen as complex megaprojects, with the Berlin 1936 Olympics often being cited as the first case of upscaling the Olympics to a mega-event, which generated a desire to present these events in a new grand schema.

The Olympics could be deemed to be a ‘classic’ megaproject as they have all the features – time constraints, a budget that needs to be maintained, politics, economics, stakeholder interests, a diversity of other actors with varying levels of empowerment and disempowerment, in addition to issues associated with a highly concentrated temporality as well as the longevity of the assets and their further use after the event is over.

Innovation and Diffusion of megaprojects

Megaprojects are subject to cycles and fads, on a large scale.

“When these projects are viewed historically and situated within a global context, the cyclical nature of urban mega-project development comes into clearer focus. Indeed, there are a variety of common cycles of mega-project innovation and diffusion that can be identified”.
(Siemiatycki, 2013:162)

Economics urban planning, cost of urban land

Megaprojects have also been linked to large-scale urban development and shifts in ownership to large corporations or from the public to the private sector (Sassen, 2016). These megaprojects conjure up the notion of large scale or global “real estate”, affecting large populations through geographic and economic dislocation. At the core of this dislocation are the ways in which the fundamental needs of different stakeholders are variously accounted for.

4. Citation analysis

A citation analysis for 2011-2016 was undertaken, to gain a schematic picture of how the term ‘megaproject’ traversed different areas of literature. There were literature reviews/bibliographic analysis previously published for the topic of Megaprojects with a focus on Construction Engineering and Management (CEM) for the period 2000-2010 (Hu et al, 2015) and 2008-2011 (Peng et al 2012). These reviews served as a general background on the issues and themes covered in the years preceding and as aids to assessing developments in more recent years within the timeframe of this research.

The databases used

- Web of Science (WoS - v5.22.3) – this database was used to capture the wider disciplines, topics and themes for citation analysis. WoS allowed a glimpse into all

areas and disciplines where megaprojects were mentioned, along with associated terms. This allowed an exploration which was not purely focused on CEM.

- Business Source Complete – this database was used to focus on a specific business and management view of megaproject for the literature review

Although WoS and BSC were the main databases used, Scopus and Factiva were also used to enhance some elements of the literature review.

- Scopus – wider focus, analytics
- Factiva – to gauge the topics discussed in past 5 years in much wider publications, also looking at what has been newsworthy (search conducted 01 August 2016).

Each database had specific criteria and parameters, which varied across the different databases. The citation analysis provides an amalgam of findings across all searches.

A number of key terms were gleaned from the initial literature search (Flyvbjerg, 2014). The terms identified were searched in field tags for “Topic” and also if the terms were contained in the “Title”.

Database	Field and No. items	Terms
Web of Science	TS= Topic (398)	Primary: “Megaproject” OR “Megaprojects” OR “Mega project” OR “Mega projects” OR “Mega-project” OR “Mega-projects”
	TI= Title (155)	
	Primary combined: 398	
	TS= Topic (1174)	
Web of Science	TI= Title (104)	Additional: “Complex project” OR “Complex projects” OR “Large project” OR “Large projects” “Large-scale program” OR “Large-scale programs” OR “Large-scale programme” OR “Large-scale programmes” OR “Large program” OR “Large programs” OR “Large programme” OR “Large programmes” OR “Major program” OR “Major programs” OR “Major programme” OR “Major programmes”
	Additional combined:1174	
	All sets combined = 1558	
	Refined: 783	
Business Source Complete	AB = Abstract	
	TI=Title (114)	
	KW = Keyword	
	Scholarly peer reviewed: 157	
Business Source Complete	Trade/Magazine publications: 147/55	
	Primary combined: 404	
Scopus	TITLE-ABS-KEY	
	= 1459	
Scopus	Refined: 672	

Factiva	Primary in title or leading paragraph:	
	Total count: 7295	

Table 2 – Summary of database searches

Web of Science (WoS)

WoS Citation analysis – sub areas

Refined searches: a number of sub-areas were excluded to focus on relevant megaproject research area. Non-related articles, where the primary focus was not on megaprojects despite the specific terms coming up in the search, were removed. The search identified almost 100 areas of research where the term megaprojects were noted in the TI and TS field. A number of these were excluded such as astronomy and astrophysics, food science technology, clinical science, epidemiological studies etc. This yielded a total of 783 items.

When specifically focussing on megaprojects as a word in the title of the article or supplied as a topic term, there are **398 items** which give a more defined picture of a number of subareas as outlined below.

1. Most cited articles with citation counts (WoS) (2011-2016)

Flyvbjerg, 2014b was the most highly cited paper in the top 1% of its academic field based on a highly cited threshold for the field and publication year. (Data from Essential Science Indicators on WoS).

The primary combined search (398) was filtered for citation counts – high to low (again another level of exclusion occurred for non-relevant items).

Journal Article Title	Authors	Source Title	Publication Year	Total Citations
1. What You Should Know About Megaprojects and Why: An Overview	Flyvbjerg, Bent	PROJECT MANAGEMENT JOURNAL	2014	42
2. Should we build more large dams? The actual costs of hydropower megaproject development	Ansar, Atif; Flyvbjerg, Bent; Budzier, Alexander; Lunn, Daniel	ENERGY POLICY	2014	39
3. Risk, uncertainty and governance in megaprojects: A critical discussion of alternative explanations	Sanderson, Joe	INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	2012	38
4. Keeping it simple? A case study into the advantages and disadvantages of reducing complexity in mega project planning	Giezen, Mendel	INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	2012	23
5. State dirigisme in megaprojects: governing the 2014 Winter Olympics in Sochi	Mueller, Martin	ENVIRONMENT AND PLANNING A	2011	22
6. Maximizing strategic value from megaprojects: The influence of information-feed on decision-making by the project manager	Eweje, John; Turner, Rodney; Mueller, Ralf	INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	2012	18
7. Managing Structural and Dynamic Complexity: A Tale of Two Projects	Brady, Tim; Davies, Andrew	PROJECT MANAGEMENT JOURNAL	2014	16

8. Providing cleaner energy access in Indonesia through the megaproject of kerosene conversion to LPG	Budya, Hanung; Arofat, Muhammad Yasir	ENERGY POLICY	2011	16
9. Behind an ambitious megaproject in Asia: The history and implications of the Bakun hydroelectric dam in Borneo	Sovacool, Benjamin K.; Bulan, L. C.	ENERGY POLICY	2011	15
10. Articulating Intra-Asian Urbanism: The Production of Satellite Cities in Phnom Penh	Percival, Tom; Waley, Paul	URBAN STUDIES	2012	13
11. Project complexity and systems integration: Constructing the London 2012 Olympics and Paralympics Games	Davies, Andrew; Mackenzie, Ian	INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	2014	12
12. Planning a Future for Phnom Penh: Mega Projects, Aid Dependence and Disjointed Governance	Paling, Willem	URBAN STUDIES	2012	12
13. Urban mega-projects for a 'world-class' riverfront - The interplay of informality, flexibility and exceptionality along the Yamuna in Delhi, India	Follmann, Alexander	HABITAT INTERNATIONAL	2015	8

Table 3: WoS most cited articles with citation counts

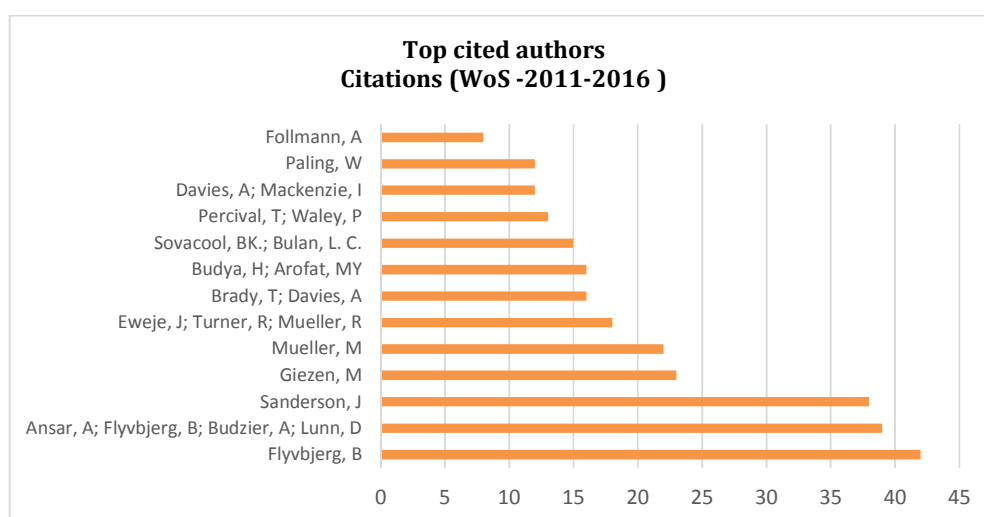


Figure 1: Total citation for authors (Oct 2016)

Another search was conducted on WoS for the top authors across the set for record counts. This was an item set by the parameters of the database. This table highlights top authors within this search were as follows:

Top author record counts – i.e. number of records on WoS

Author	Record count	% of articles
HU Y	7	1.759 %
CHAN APC	5	1.256 %
KHARITONOVA V N	5	1.256%
LE Y	5	1.256
FLYVBJERG B	4	1.005 %
GIEZEN M	4	1.005%
SOVACOOOL BK	4	1.005%
CHANG A	3	0.754 %
DAVIES A	3	0.754 %
DOUCET B	3	0.754%

Table 4: Record count for authors (WoS, 2011-2016)

Although Flyvbjerg is positioned lower in the list of record counts, in the citation counts for the same set, he tops the author list.

2. Country of origin of megaproject articles published

Table 5 highlights the origins and regions from which publications are coming from. The top four countries listed include Australia. This result highlights Australia as a dynamic country in terms of publication output on megaprojects. The top two countries are USA and England.

Countries/Territories	Record count	Percentage of total items
USA	55	13.819%
ENGLAND	44	11.055%
NETHERLANDS	29	7.286 %
AUSTRALIA	26	6.533 %
PEOPLES R CHINA	26	6.533 %
CANADA	23	5.779 %
BRAZIL	13	3.266 %
MEXICO	12	3.015 %
GERMANY	11	2.764 %
SOUTH AFRICA	9	2.261 %

Table 5: Records ranked by Country (Top ten)

3. Research Institution publishing articles

Institutions listed in the publications are highlighted in Table 6. Amsterdam University tops the institutions for record count.

Institution	Record count	% of total items
Univ Amsterdam	11	2.764 %
Univ Oxford	9	2.261 %
Tongji University	8	2.010 %
University of California System	8	2.010%
University of London	8	2.010 %
University of Oxford	8	2.010 %
Univ Utrecht	7	1.759 %
Delft University of Technology	6	1.508 %
Hong Kong Polytechnic University	6	1.508 %
University of Technology Sydney	6	1.508%

Table 6: Records ranked by institution

4. Publication years

Record count for publication for the years 2011-2016. Note that 2016 is not indicative of the total and only includes counts to October 2016.

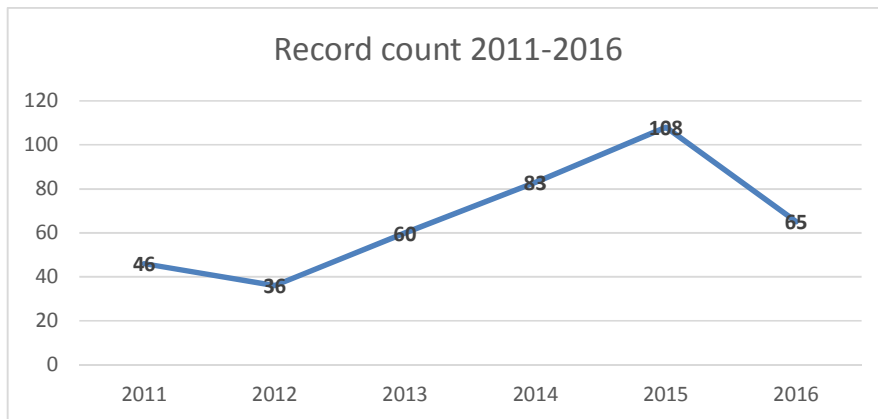


Figure 2 – Number of publications (2011-2016)

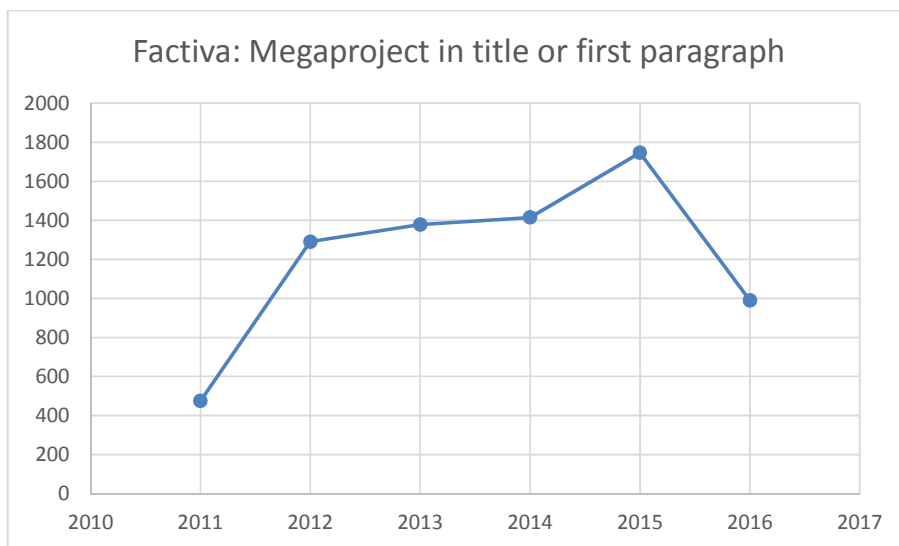


Figure 3 – Factiva: Megaproject in title or leading paragraph (2011-2016)

5. Top ten journals publishing on megaprojects (WoS) by record count

Journal title	Record count	% of total items
International Journal of Project Management	24	6.030 %
Habitat International	13	3.266%
Project Management Journal	8	2.010 %
Region Ekonomika I Sotsiologiya	8	2.010 %
Cities	7	1.759 %
International Journal of Urban and Regional Research	7	1.759 %
Energy Policy	6	1.508 %
Journal of Construction Engineering and Management	6	1.508 %
Journal of Management in Engineering	6	1.508%
Korean Journal of Construction Engineering and Management	6	1.508 %

Table 7: Top ten journals publishing on megaprojects

6. Top journals publishing on megaprojects (WoS) by citation count of most cited papers

The top journals by citation count (2011-2016) are as follows:

1. International Journal of Project Management
2. Energy Policy
3. Project Management Journal
4. Urban Studies
5. Environment and Planning A
6. Habitat International

When compared to **Table 7**, it is interesting to note that a number of journals such as Cities, Korean Journal of Construction Engineering and Management and Region Ekonomika I Sotsiologiya do not show up for the higher citations despite having higher representation in record counts. From a comparative analysis, **International Journal of Project Management** is significant in both representation on the WoS database and citations.

The citation statistics may show a bias due to the sampling criteria. Had we used more generic terms such as complex systems or complexity we would have produced a differently skewed sample, oriented perhaps more to fields such as organization theory.

6. Research areas of megaproject articles in journals

Research areas	Record count	% of total items
Business Economics	130	32.663 %
Environmental Sciences Ecology	116	29.146 %
Geography	94	23.618 %
Public Administration	76	19.095 %
Engineering	72	18.090 %
Urban Studies	59	14.824 %
Government Law	43	10.804 %
Social Sciences other topics	36	9.045 %
Construction Building Technology	28	7.035 %

Energy Fuels	26	6.533 %
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Table 8: Research areas of megaproject articles in journals

Business Source Complete (BSC)

BSC was used to determine differences in a number of areas of the citations for the term megaproject. It allowed for a more detailed view of the landscape differences between practitioner areas and academic areas.

Terms were searched in the abstract, title and keyword field using the term Megaproject and its variations. A total of 404 items were found. Articles include academic scholarly peer reviewed (157), trade publications (147) and Magazines (55). The citation analysis confirmed the view that academia and industry (through topics covered in the publications) were both committed to the exploration of megaprojects as a phenomena on many different levels from financial, economic to social and entrepreneurial areas.

Factiva

The Factiva search yielded 7295 counts of the primary terms in the title of lead paragraph. As Factiva is mainly a search of news items it highlighted new topics around megaprojects. The search was conducted in August 2016.

The most dominant themes concerned domestic and regional politics and political news in general. Other subjects to emerge included megaprojects being mentioned in the contexts of Corporate/Industrial News; Plans/Strategy; Transport; Regulation/Government Policy; Urban Planning/Development; Contracts/Orders; Environmental News; Capacity/Facilities and Facility Openings. There were also themes of Corporate Crime/Legal Action and International Relations, Partnerships/Collaborations and Contract Tenders spread across the documents found.

5. Common Problems

Areas already identified in the literature

Merrow (2011) succinctly identified and classified common problem areas in megaprojects, albeit that they were for large industrial projects. That said, the commonalities and propositions put forward prove useful, in developing a picture of issues, which are at the heart of megaprojects in general. These include:

- Greed and how this manifest in megaprojects.
- Schedule pressures—cutting corners, opportunism.
- The need to develop a business case early in the life of the megaproject.
- The need for stronger planning at the initial phases, costs to be realistically incurred
- Cost reductions without respecting the scope definition
- Rethinking the contractors obligations – issues of transferring risks to contractors
- Continuity issues - project managers changing lack of continuity (Merrow, 2011).

The areas identified by Merrow focuses on addressing specific problem issues. Chief amongst these were the following:

- Governance – needs for transparent processes, robust governance, ethical considerations, communication strategy
- Contract design, ambidextrous project management, developing the front end of the project with deliberation and effort

Building on the Iron triangle

In the past 5 years the emergence of a consistent view of common problems surrounding megaprojects has seen the emergence of a new perspective enveloping a more complex view of the volatility of current global environments from which megaprojects emerge. This includes economic, environmental and psychological elements, taking into account the complex systems in which managers and leaders are now expected to engage. It is no longer just a question of being on time, within budget and scope.

Building on analysis to date, what are the factors and actors that influence performance?

Table 9: Megaprojects and the main problem areas identified (adapted from Table 1 in Klakegg et al, 2016)

AUTHOR	PROBLEM	PROBLEMS AND AREAS IDENTIFIED
Peter Hall (1981)	Decision-making models Roles/actors	- Forecasting the future - Trade-offs between groups
Morris and Hough (1987)	Different perspectives on project success	- Human errors - Project objectives and their validity - Influence of politics - Government as sponsor, champion, and owner - Financial matters - Implementation of results
David Collingridge (1992)	Decision-making processes in big organizations Trial-and-error learning	- Limitations in human capacity to control and understand complexity - Problem changes over time - Inflexibility in technologies (projects) - Changes are costly and painful—inhibit critical scrutiny
Miller and Lessard (2000)	Institutional frameworks, decision-making, and project sponsoring	- Handling turbulence in project environments - Opportunism and omission - Decision-making is not fully rational - Coordination and cooperation - Design of institutional frameworks
Flyvbjerg et al. (2003)	Better and more rational decision-making and communication Institutional arrangements, accountability, and handling risk	- Applying the wrong method is a minor reason for forecasting failures - Poor data are a more important for predicting failures than methodology - Discontinuous behaviour and the influence of complementary factors not included in predictions - Unexpected changes of exogenous factors - Unexpected political activities or missing realization of complementary policies - Appraisal bias of the consultant and the project promoter
Altschuler and Luberoff (2003)	Theoretical analysis National patterns over time Intergovernmental aspects	- Lack of competence and experience transfer - Handling complex networks of practices and roles

		<ul style="list-style-type: none"> - The public sector leadership role - Handling harmful side-effects - Conflict between local support and central financing - Project financing models - Cost escalation and underestimation
Last 5 years		
Merrow (2011)	Understanding projects Business decisions before starting projects Making project decisions	<ul style="list-style-type: none"> - Unbalanced allocation of value-greed - Schedule pressure—cutting corners, opportunism - Developing a detailed business deal early - Weak planning upfront - Cost reductions without respecting the scope definition - Trying to transfer megaproject risks to contractors - Firing project managers for cost overruns—lack of continuity
Morris (2013)	History of project management Management of projects Aligned supply: focusing on value	<ul style="list-style-type: none"> - Realization of business outcomes - Relevance of project management in light of global changes and challenges - Shaping the context to allow project success - Alignment of suppliers and sponsors
Hart (2015)	Dealing with large project government contracts Project Director managing procurement	<ul style="list-style-type: none"> - Clarity of objectives - Dedicated focus of project director - Human element – best talent needed - identifying scope in real terms - Allocating risks to the right people - procurement needs design and planning - Consultation crucial - Insistence on robust governance - See difference between “price” and “value” - As project manager, know your limitations
Flyvbjerg (2014b, 2016)	Conventional megaproject delivery – is highly problematic with a dismal performance record in terms of actual costs and benefits	<ul style="list-style-type: none"> - Megaprojects are inherently risky due to long planning horizons and complex interfaces - Often projects are led by planners and managers without deep domain experience - Manager changing throughout the long project cycles that applies to megaprojects leaving leadership weak. - Decision-making, planning, and management multi-actor processes involving multiple stakeholders, public and private, with conflicting interests (Aaltonen and Kujala, 2010). - Technology and designs are often non-standard, leading to "uniqueness bias" impedes learning from other projects - Frequently there is over-commitment to a certain project concept at an early stage, resulting in “lock-in” or “capture” leaving alternatives analysis weak or absent - Due to the large sums of money involved, principal-agent problems and rent-seeking behaviour are common, as is optimism bias (Eisenhardt, 1989; Stiglitz, 1989; Flyvbjerg et al., 2009). - The project scope or ambition level will typically change significantly over time. - Delivery is a high-risk, stochastic activity, with overexposure to so-called "black swans," i.e. extreme events with massively negative outcomes (Taleb, 2010). - Statistical evidence shows that such complexity and unplanned events are often unaccounted for, leaving budget and

		time contingencies inadequate. - Misinformation about costs, schedules, benefits, and risks is the norm throughout project development and decision-making.
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6. New areas of focus for Megaprojects and revisiting previous themes

In terms of dominant areas to emerge as significant key themes for research and application on the topic of megaproject, the following empirical foci require further detailed consideration. These areas typically dovetail in strengthening megaprojects. Number one is a further exploration of institutional analysis, reforming of institutional focus and the need for institutional forms with powers to coordinate megaprojects activities on a national and global level. This includes looking at relevant issues around:

- Governance
- Stakeholder issues
- Collaboration and understanding between technical and business personnel (Merrow, 2011)
- Networked knowledge between industry and academics
- Design led thinking and co-creation on projects
- Complexity, volatility of global environment
- Reforming notions of procurement, contractual issues
- Exploration of different models for supply and demand networks and connections
- Leadership as a priority in megaproject - reflexive practitioners, design led innovation, engineers, managers and leaders

Based on the discussions thus far a number of analytical areas suggest themselves as major areas for future research focus. We identify the following areas as critical.

- Context: the context of megaprojects, how it is shaped, how the megaproject's unfolding interacts with context and recursively reframes the context, creating a more or less stable 'political' environment for the project
- Procurement: failure to fully understand the procurement process in the development of megaprojects can lead to disproportionate level of problems. Hart (2015) outlines that the ability to detect weakness in the initial stages of large government contract being executed, and the ability to address these weaknesses early in the procurement process, can lead to more successful megaprojects (Hart, 2015:4).
- Institutional perspectives: how do megaprojects shape institutional frameworks and how do institutional frameworks frame megaprojects? Megaprojects will often be situated in the midst of competing and sometimes contradictory institutional logics, which Thornton and Ocasio (1999: 804) define as "the socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality". The institutional field is invariably pluralistic. In complex institutional fields different practices, values, beliefs, rules and senses of temporality, materiality and spatiality can all come into

play. Who and what are the institutional entrepreneurs that launch megaprojects? What strategies with what rhetoric do they use to make their case? What are the consequences in terms of the major variables of the different strategies and rhetoric?

- Constituting megaproject cultures: Creating collaborative practices between clients, stakeholders and contractors in megaprojects adds to complexity. We need more research on how to establish cooperation regimes in these large projects and programs and how to understand and improve the dynamics of cooperation, often tied up with the legal and contracting forms governing the collaboration. Findings from a longitudinal ethnographic study of public–private collaboration in the Dutch construction industry in the period 2006–11 (van Marrewijk et al, 2014) found the significance of cultural relevance and communication with diverse stakeholders. Other research has pointed to the importance of a designed culture for the megaproject (Clegg et al 2002).
- Coordinating disciplinary knowledges: any megaproject requires considerable boundary work in terms of disciplinary knowledges and considerable translation between them. What are the key boundary objects facilitating coordination and how are they used (Naar and Clegg 2017).
- Becoming megaproject managers: what processes are instituted, how do managers learn to manage complex emergent processes (see Bjorking et al XXXX)
- Financing megaprojects: how finance arrangements shape management and organization of megaprojects and their subsequent success or failure.
- Lifecycle costs and projects: how is the megaproject lifecycle calculated, with what consequences?
- Megaproject leadership: how does leadership operate in contexts marked by pluralities of organizations, stakeholders, and their respective leaders? What is the role and what are the practices of the project leader and the project leadership teams (Pitsis et al 2003)?
- Megaproject paradoxes and politics: Critical to the success of a megaproject is the need for sensitivity to ethical concerns. This relates to problems in balancing the interests of various stakeholders in an ethical and pragmatic manner, it also connects with the need for robust governance mechanisms agreed upon by all stakeholders early in the phase of megaproject development. “Projects are a mixed blessing for democratic politics” Keane (2012:660) states, when he articulates another paradox of megaprojects: that the power relations embedded in their existence are based on agreed upon activities in a democratic society, yet at the same time “power relations embedded within the megaproject come wrapped in a canopy of multiple realities; hidden agendas are protected by various efforts at producing silence that functionally depends upon volumes of public rhetoric, things being said and displayed to the outside world” (Keane, 2012:662).
- Megaprojects and sustainability: On 9th March 2015, a group of concerned citizens, including: “farmers, scientists, authors, philanthropists, Indigenous leaders, and opinion setters” sent a letter to the G20 outlining a number of critical concerns with the increasing level of investment in megaprojects (Sign-on letter to the G20 March 9, 2015, Regarding: G20 Plans for Infrastructure Finance). The letter outlined the

perils of continuing down the path of creating more and more megaproject at a cost to the environment and its communities. The demand for more sustainable projects is hardly likely to abate. With the increasing population of major cities globally, the need for megaprojects is not abating. Global cities and their elites frame and assert the need for megaproject building and development and its accompanying (expected) economic growth. The main impetus driving this force is the desire for ‘spectacle’ linked to the economy of these cities. These developments entail an increased demand for energy – where there is an exponential growth in the number of energy generating infrastructure projects and accompanying levels of investment. There are issues with security about the ownership, development and creation of these types of projects. Amongst these are ‘nuts and bolts’ issues of sustainably supplying the needs of a city’s growing population and the inherent desire for the expansion of cities, i.e. energy, water, housing, transport, health, social aspects entertainment and sport.

- Global megaprojects: because of the ever-growing demand for the construction of megaprojects, developed countries have a significant advantage in research on megaprojects, due to their relevant experience, including countries such as the United Kingdom, Australia and the United States. Hu et al (2015) outline that research in developing countries such as Russia, India, Turkey, Vietnam (Hu et al 2015) is lacking. The needs of developing countries foreground the global landscape, with developing countries predicted to invest another \$22 trillion in infrastructure (2008-2017) (Economics, 2008 as cited in Hu et al, 2015). Projects that are large scale; complex and ambiguous, involving multiple stakeholders, will continue to pose major problems of juggling limited resources, conflicting terrains and diverse stakeholders
- Megaprojects and Disruptive Technologies: Some flexibility must be built into large infrastructure project timelines and planning to allow for benefits to be derived from technology improvements. As an extreme example costly desalination plants were superseded by far more effective and less expensive membrane technology that was developed prior to the completion of commissioned desalination plants.

7. Solutions and Value Propositions

Despite the ever increasing issues presented by megaprojects, the fact is they are a reality of the 21st century. Developing solutions and dialogue around how to improve on issues related to megaprojects is a vital concern. The next section briefly discusses some areas and value propositions.

An Organizational Learning focus

According to Flyvbjerg (2016), megaprojects keep on repeating the same mistakes. This suggests that insufficient organizational learning is occurring that can offer better access to systems that work in specific megaprojects as repositories of knowledge that are useful. Learning across megaprojects needs to be linked to specific similarities in characteristics and features, taking into account stakeholders, governance, sustainability etc. Data bases that are repositories of processes, designs, problems and solutions need to be developed.

Learning from the past: aggregating past insights

Learning from the past is critical (Lenfle & Loch, Forthcoming, 2016:1). Hayes (2011) outlines the significance of ‘sustained leadership and accountability systems’ in literature on megaprojects. She outlines a concern for the need to draw from past lessons and to “figure out a way to aggregate our acquired insights and tell the stories in a way that is accessible to those on the front lines” (Hayes, 2011:197)

Networked information

Solutions and experience (creation of international databases) are promoted that might possibly tap into pre-existing data collection i.e. see COST – European Cooperation in Science and Technology which was set up in 1971 by 19 member countries and currently includes 35 member countries. COST is an intergovernmental framework aimed at facilitating the collaboration and networking of scientists and researchers at a European level: see their research framework.

Longer terms evaluation of projects

These include the development of surveys and evaluations that capture what works and what doesn’t work for specific types and sectors i.e. “Project Close-Out Stage” (Fahri et al 2015) – evaluation beyond project close – reassessing the parameters of what a successful project is and taking into account evaluation criteria and other criteria for evaluation (Lehtonen, 2014)

Rethinking governance as situated and relational, not static

The significance of good governance to alleviate pressure points in the project is widely recognised. This area is a foundational aspect of megaprojects and is a cohesive element of many of the disparate aspects that make up the megaproject’s successes or failures. “We must give proper attention to the ways in which project governing happens in a situated, relational sense, rather than just focusing solely on governance as a set of pre-designed.

Governance in a technically rational domain may need rethinking in terms of ideas about the “reflexive practitioner” and the usefulness of design thinking in creating collaborative focus. Procurement process and contract needs time spent on “design and development” in addition to the design and development of the actual megaproject (Hart, 2015). The role of the Project Director, as someone fully dedicated to the project on a full time basis that spends time in the initial phases identifying potential issues (Hart 2015) has also been suggested as an area for further development. Redesigning the concept of contractual relationship, even the idea of what a contract is in megaprojects, is important as pioneering research by Pitsis et al (2003) suggests. There is a need to link the whole area of megaproject management more closely with complex systems and complexity theory, taking into account new ways of working with systems thinking, along with incorporation of institutional theory as the theoretical foundation (in stakeholder management, project planning and procurement and project monitoring and control) for developing megaproject research further (Hu et al, 2013).

Appendix: Case Studies

Trio of Stadiums in Sydney³

Background: In September 2015, Premier Baird and Mr Ayres announced a commitment to new infrastructure that included a trio of stadiums: in Parramatta, Moore Park and an indoor arena to serve the inner city, CBD.

Objectives of the proposal: development of stadiums for sports events in Sydney. Creation of a new indoor arena to replace Entertainment Centre.

Issues:

Subsequent to this announcement, it did not take long for the Premier to backtrack on the proposal to build the stadium at Moore Park. This was due to disagreements with Sydney rugby league teams and their 'revolt' against plans, highlighting the need for consultation and engagement with relevant stakeholders and their economic interests.

Another element of 'stadium strategy for Sydney' was the construction of an indoor arena to replace the Entertainment Centre. It became obvious that the business case development for this project proved to be weak with the change of ownership of the basketball team Sydney Kings. This change was critical as the new owners of the team also owned Qudos Bank Arena (previously Allphones Arena) that, in effect, dominated the selection of a preferred venue for any indoor events played by the Sydney Kings. This case highlights the volatility of ownership, function and business case analysis. Government interests (vote seeking) and corporate interest often clash.

Core issues contributing to problems:

- Stakeholder interest not considered
- Power relationships in the sporting financial landscape
- Owner of real estate affecting dealings and progress
- Political promises for votes
- Failure to consider the logistics of various aspects of sporting venues
- Front end planning and business case not developed adequately

This is a current and ongoing project and as such will be interesting to follow.

Cross City Tunnel⁴

Optimistic estimates of projected usage of Cross City Tunnel versus actual usage

Background: The initial concept of the tunnel was discussed in 1998 (Cross City Tunnel Pty. Ltd., 2007). Eight consortia expressed interest by 23 October 2000 and on 27 February 2002, it was announced that the Cross City Motorway Pty. Ltd. was the winning consortium.

³ Case compiled from: <http://www.smh.com.au/nsw/bairds-plan-sydney-will-fill-the-new-stadiums-if-not-the-old-20150904-gjffqo.html> and <http://www.smh.com.au/nsw/premier-mike-bairds-inner-city-indoor-arena-could-be-scraped-like-moore-park-stadium-20160724-gqcgny.html>

⁴ Case information compiled from (Chan et al, 2008)

Consortium included financiers, Cheung Kong Infrastructure of China, Bilfinger Berger of Germany and RREEF Infrastructure of Australia

Objectives of CCT: Reduction of traffic in Central Sydney and as a result easing traffic congestion and improving environmental amenity in the CBD and to improve the east to west traffic flows. The project involved the construction of a 2.1 km twin two-lane motorway east and west beneath central business district of Sydney. The project sum: \$AUD680 million.

Public Private Partnership (PPP) with a design-build-operate (DBO) arrangement under a 30-year concession agreement. The project was started: 28 January 2003 and delivered ahead of schedule i.e. officially opened on 28 August 2005.

Issues:

- High levels of expectations
- Traffic forecast for the tunnel was predicted to be 90,000 vehicles per day.
- To encourage the use of the tunnel there was a 3 week free toll period overcome the low usage of the tunnel, the free toll was further extended for 2.5 weeks. The tunnel usage during this period increased to 53,000 vehicles per day. Despite this attempt to increase usage the number of vehicles dropped by almost 50% when the toll was reinstated (Smith, 2005; Wikipedia, 2006) (cited in Zou et al 2008)

The core issues that contributed to the failure of the project included:

- Inaccurate traffic forecasts;
- High toll levels;
- Government closing off the surface roads to direct the traffic into the CCT;
- Flawed concession agreement;
- The public client and the private consortium arguing openly in public;
- No toll subsidy or compensation from the government;
- The toll level, possibility of a Government contribution was not open to negotiation

8. Conclusions

Understanding some of the mechanisms behind the technical issues is only part of the story for improving the completion of megaprojects. The impetus for the ongoing development of megaprojects is a complex convergence of social, economic, engineering and scientific ventures.

The issues raised in this paper bring into question the need for value and competitive advantage on a much different level. Megaprojects occupy an important place in global relations and drive a number of explicit and implicit economic agendas. The multitude of tasks that bring them to the point of completion is an illusion, as megaprojects are entities of an ongoing nature. In reality, all tasks associated with the development of megaprojects are connected to complex practices that require a dynamic and ambidextrous way of thinking around projects and the manner in which they are carried out.

The contemplation of megaprojects paradoxically brings into light a vortex of positives and negatives, depending on the elements at play and the technical and business competence of

those involved. They are seen as a force of massive prosperity and economic success for stakeholders. They are also seen as destructive forces of doom and massive failure, outmoded projects in a time where resources are scarce and environmental concerns dominate.

The uncontrollability factor lies at the crux of megaprojects and the compelling need to seek mastery in the form of highly competent technical expertise and engineering brilliance – This paper has explored some of the ways humanity seeks to tame these juggernauts of mixed blessing, better known as megaprojects.

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