Chapter 22
"Megaprojects to Mega-Uncertainty" Is About Risk Management to Perform

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22.1 Introduction

Traditional project management methodologies revolved around sound technical and procedural factors, like scheduling, scoping, budgeting, risk management and quality assurance, amongst others. However, a high percentage of projects are still being reported as failed even with the use of these well-established methodologies and frameworks. In the case of megaprojects, only 35% succeed (Merrow, 2011), characterised as economical, technological, aesthetic or political (Flyvbjerg, 2013). Evidence confirms, based on the most common project success indicator, that only approximately one in a thousand projects manages to deliver on all three targets, illustrating that the success rate is dismissive (Flyvbjerg, 2017). This paper objects this destructive and dictated view because it builds a negative perspective on the performance of megaprojects.

These projects deserve better evaluation models, considering they normally attract investments well above $1 billion worth and include most likely intangible benefits, appealing long-term outcomes and very uncertain conditions ((Müller et al., 2012). The most common causes for these failures have directly been linked to cost and schedule overrun (Kaming et al., 1997), business case and scope creep (PMI, 2016), uncertainty (Lock, 2003), strategic risk (Forbes, 2017), risk management (Oyegoke, 2019), criticality of people (Dvir et al., 2006) and perceptions and project complexity (Liu et al., 2016), amongst others.

Megaprojects are regarded as a multi-trillion-dollar global delivery model for large investments for most industries (mining, mineral processing plants, oil and

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gas, IT, supply chains, aerospace, defence, mega-events like Rugby World Cup). It affects the way we shop as consumers, our energy bills, ways of travel and how we use everyday technology like the Internet. The current conservative valuation for the global megaproject market is USD 6–9 trillion per year, (Flyvbjerg, 2014). Frey (2017) continues to predict that megaproject spending will escalate within the next decade to around USD 22 trillion per year accounting for 24% of global gross domestic product (GDP). In this perspective that is larger than any nation's GDP including China and America. Recently the largest project (China Belt) costs well over USD 1 trillion. That is more than the total market capitalisation of Apple.

The current global pandemic has further intensified the issue and put the performance of megaprojects to its thorniest lifetime test yet, with megaprojects announced exponentially at all levels for social reconstruction and economic reform after the devastating impact of COVID-19. The outcomes (benefits and value) will be expected to be preserved for many years to come, considering the huge sacrifices made in terms of time, cost and scope. The audiences and stakeholders of these immediate projects will critically evaluate these projects' successes based on outcomes delivered, not on the time and not on the initial investment required; change is demanded and expected to be delivered at the sacrifice of time and cost. Roles of politicians changed overnight where they have become the steering project managers with a global audience and the fate of many lives depending on their navigations. The risk management employed throughout the pandemic will be crucial for the better value of life itself, with the outcomes impacting millions of lives not just today, this year or when a vaccine is available but for many generations to come. Worries are growing about GDP depletions, economic retractions, social value exploitations and serious health risks. Now with megaprojects identified as a delivery tool for major change and developments, the pressure to perform whilst preserving value has never been so significant.

Academic knowledge in megaprojects has therefore become more crucial considering the substantial impact big projects have socially, economically and environmentally (Flyvbjerg et al., 2003). Immediate, research attention is therefore required to better understand why the current theory in particular 'the iron triangle' is not enhancing performance but instead risks the deliverance of better outcomes for the staggering 90% failing megaprojects (Merrow, 2011) by enabling uncertainty and subsequently risk based on the findings of this paper.

According to Bryde (2008), are not only the most cited but also the most used Iron Triangle criteria measures of project success. In their study relating to the project manager's experience of projects, White and Fortune (2002) found that the iron triangle was used as a primary way of defining project success by most project managers. Research by Müller and Turner (2007) stresses how the iron triangle is valued by both inexperienced and experienced project managers. This persistent popularity may be as a result of its simplicity. Subsequently explained by Jugdev

and Müller (2005) that when projects are delivered to these criteria, the declaration of success seems relatively simple or perhaps too simple for complex models like megaprojects to serve an effective purpose.

This paper is linked to a broader risk management research stream initiated and supported by Leeds Beckett University for PhD studies. The paper firstly recognises the failure or success indicators for megaprojects and then explores how these factors are incorporated or dealt with when evaluating performance analysing nine UK-based case studies:

(1) Firstly by the iron triplets. (2) Secondly by considering the increased complexity and uncertainty of megaprojects in contemporary global project environments. The paper finally concludes that the data represented although not scientifically significant offer hope for a broader perspective of risk management to better influence the performance of megaprojects. Several hypotheses are drawn upon that call for more research and academic collaboration.

22.2 Literature Review

The so-called megaproject pathologies, i.e. the chronic budget overruns, and failure of such projects have highjacked the focus of literature, and relatively diminutive devotion has been given to the specific needs of evaluating large projects. This paper suggests that conceptualising megaprojects as both evolving and dynamic systems would provide a useful basis for performance evaluation. Literature is therefore drawn from two strands, success and failure criteria of megaprojects and how evaluation for megaprojects might improve.

22.2.1 Project Performance Evaluation

Many government reports demonstrate that projects have been judged against time, cost and scope criteria (see IPA, 2017 report), and the results have not been promising, with nearly 65% of megaprojects failing to point out ICT projects have been particularly inclined to failure, with high percentages (around 80%) (Savolainen et al., 2012). Lastly, performance evaluation and transport infrastructure projects can be controversial according to Ika (2009), whilst Turner et al. (2012) reckon it is related to the time frame and stakeholder's perspective.

Turning a blank eye on the ongoing ambiguity that exists regarding the determining factors for project success will continue to have significant consequences for how megaproject 'success' and 'failure' are defined, subsequently risking future stakeholder value or existing value depletion.

	Project Criteria for Mega Projects							
Variables	Iron Triangle 1969	Kliem&Ludin (1992)	Atkinson (1999)	Nelson (2005)	Prince 2 (2009)	Pinto (2010)	PMI PMBOK (2013)	Williams et.al. (2015)
	Time	Time	Time	Time	Time	Time	Time	Time
	Cost	Cost	Cost	Cost	Cost	Cost	Budget	Budget
	Scope	Scope	Scope	Product	Scope	Quality	Scope	Quality
		Soft Aspects	Quality	Value	Benefits	Client acceptance	Requirements	Client satisfaction
				Use	Quality		Quality	Client relationship issues
				Learning	Risk		Risk	

Fig. 22.1 Chatelier (2020)—Project criteria suggested over time adopted

22.2.2 A Review of the Iron Triangle

The 'triangle' has been criticised for putting too much emphasis on cost, time and scope. Not only does this limit the evaluation to other important factors like risk, benefits, value, stakeholders, etc. but narrows perspectives of how the project manager or practitioner is being appraised or rewarded for their capabilities to meet these criteria (Wateridge, 1998). Several authors had suggested some improvements; see a summary below in order of publication.

These adaptions, therefore, emphasise the inadequacies of this widely accepted method (Fig. 22.1).

The weight assigned to the Iron Triangle as the primary determinant for project success has been criticised by Atkinson (1999). He proclaimed that is a 'phenomenon' and Cost and Time 'only guesses' suggesting that the protects require a new criteria for success evaluation. This debate was supported by Gardiner and Stewart (2000), who estimated that about 50–70% of projects have a severe schedule and budget overruns, stressing that initial estimates are insufficient for weighing success, especially when used to benchmark management processes.

22.2.3 Subjectivity in Project Evaluation

It is well established that subjectivity is a factor that affects performance evaluation practices. Over the years, different methods have been projected for project evaluation complexity whilst segregating complexity away from risk (He et al., 2015). However, the recorded successes of these methods are not known especially in the context of these staggering failure rates and therefore excluded.

22.2.4 Differentiating Characteristics of Megaprojects

Accepting Characteristics and Differentiating Megaprojects

It is not news that megaprojects are different from projects due to its multi-dimensional characteristics which differentiate itself from standard projects. Additionally, Merrow (2011) sets the expectation for megaprojects to be more visual due to these characteristics. Often megaprojects are characterised by long schedules stretching over decades worth over hundreds of millions or billions often affected by an enormous amount of uncertainties and risks (Bruzelius & Flyvbjerg, 2002). These arguments should be acknowledged as they set precedent why the simplicity of the iron triangle does not compensate for the complexity of megaprojects.

Substantial Stakeholder Involvement

Megaprojects attract a lot of public attention; balancing stakeholder interest can become very political especially when there are negative implications. Numerous authors in literature have expressed the criticality of project stakeholder management for project success (Boonstra et al., 2008). Findings from Mulholland (2019) study stresses the significance of following a processual and pluralistic approach about stakeholders demonstrating the need for a more focus. As both the amalgamation and dismantle of stakeholder influences and interests as they evolve over the project life cycle, the evaluation of project success should, therefore, mirror this evolution of stakeholders.

Organisational Structure

Firstly, in megaproject sometimes referred to as meta-organisations, stakeholders/core members or investment partners join at different time intervals, and these parties have diverse priorities, beliefs, preferences and planning techniques, causing

major problems in collective action (Gil & Tether, 2011). Variance is often caused by structural changes, prone to megaprojects and not supported by the iron triplets. An automatic dissmal is triggered that might sent out a very negative view to society and stakeholder relying on the outputs or anticipated benefits.

Eccentric Cost

If delayed or altered, the cost implications could have huge significance for these projects. Flyvbjerg et al. (2003) advocate that extensive escalation of cost seems to be the norm for megaprojects, instead of the exception. Berechman and Chen (2011) accentuate risks associated with a cost overrun should be included in the decision-making process and project evaluation.

Extreme Time Delays

Influencing factors like government policies can cause major delays for these projects. Additionally, a study by Oyegoke and AI Kiyumi (2017) found that extra costs and project time overruns are the most significant effects causing delays for megaprojects in Oman, therefore supporting the argument that forecasting both estimates of cost and schedules remains difficult for megaprojects. However, such difficulty ought to be considered for performance evaluation for a more accurate and engaging reflection.

Complexity and Uncertainty

High-level complexity – Due to the uniqueness of these projects, their complexities are often not duplicated. There is a growing assumption that uncertainty is instigating complexity derived from project environments. According to the European Cooperation in Science and Technology (COST), megaprojects are characterised by 'extreme complexity (both in technical and human terms)' Cost 2018. Chatelier (2020) suggested a model additionally assumes that uncertainty is simultaneously instigating risk management.

Unique First-Time Environments

Siggelkow and Rivkin (2009) stress performance is directed referring to interactions between low- and high-level choices and environmental factors (Bingham et al., 2009). Because of the first-time initiation factor quite often, there is no prior knowledge of the political, social and technical conditions or legal and financial structures.

Ability to Derive Exponential Benefits (Author, 2020)

In his book *Megaprojects and Risk*, Bent Flyvbjerg expresses megaprojects as qualitatively significant for both economic and social development stages (Flyvbjerg et al., 2003). The definition proposed by authors of *Oxford Handbook of Megaproject Management* best applies to the context of this paper 'Megaprojects are large-scale, complex ventures that typically cost $1 billion or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people' (Flyvbjerg, 2017, p. 2).

Common consensus exists that the above dynamics have one denominator in common – direct impact on uncertainty; this general acceptance should therefore allow for these dimensions to be incorporated when evaluating project success.

22.2.5 Reasons for Megaproject Failure in Context of the Iron Triangle

Although the literature has highlighted several reasons why projects fail and even suggested solutions, not enough has been done to investigate and address the root cause of these failures as highlighted in the context of this paper with specific reference to megaprojects.

Project Life Cycle

Considering the longer delivery period (5–10 years) for megaprojects, PMI (2016) indicates that project and benefits should be tracked throughout their life cycle from the project initiation stage up to execution and post-execution. There is no evidence that once the business case has been approved, projects are tracking and monitoring intended outcomes throughout the entire project. However, such reporting might be regarded as redundant if the project was misrepresented for funding purposes. Delays cause extension of the project life cycle and raise uncertainty based on influencing variables.

Business Case

It was argued by Pollack (2007) that projects are failing due to the mismatch between the project management literature which tends to assume that success is based on 'the existence of a pre-existing business plan, with clearly defined goals and constraints, with goals that can be decomposed with clear customer requirements' (Pollack, 2007, p. 217). However, his observation was contradictory in a sense that 'highly detailed or rigid plans have been identified as limiting freedom to make decisions' (Bohle et al., 2016).

Scope Creep

Very dynamic and multi-interpretable scope may change dramatically in the course of the development process, causing simple projects to turn into a manifold of ambition and complexity with a lot of complications.

Limitations of the Iron Triangle

It was proposed by Van der Hoorn and Whitty (2015) that the iron triangle forms part of the artefacts identified in project management due to its lack of validity in relation to how projects are managed in practice.

In the construction industry, it was suggested by Collins and Baccarini (2004) that success in projects should surpass expectations for quality, cost and time objectives. Toor and Ogunlana (2010) additionally noted that other pointers such as resource efficiency, safety, effectiveness, conflict and dispute reduction and stakeholder satisfaction are progressively important for performance in construction.

De Wit's (1988) highlighted that the iron triangle will only be classified as a traditional task-related criterion, based on early research work that distinguishes between psychosocial and tasks success criteria, thus excluding criteria such as stakeholder and customer satisfaction and team relationships.

The simple use of the iron triangle overshadows its adequate contribution to practice (Chatelier et al. 2020).

22.3 Research Methodology

The methodology used forms part of the proposed research currently under development, but preliminary analysis has already yielded very interesting findings regarding the future of megaproject performance.

An extensive literature review was initially performed. Followed by an inductive cross-case analysis, the technique adopted followed a structured process by using constructed cases to arrive at 'cross-case' trends. Theoretical propositions are then derived from these 'patterns'. The approach is mainly inspired by Eisenhardt (1989); he consequently formulates a theoretical process where findings could be generalised following the review of cases of a specific domain Eisenhardt (1989, p. 545). The multiple case study approach focused on one core question (Eisenhardt, 1989): Can the performance of megaprojects be successfully measured using traditional project management theory—the iron triangle? To address the previously mentioned, the paper sought to answer a set of secondary questions including what challenges and factors had constituted the successes or failures of megaprojects? What form of organisation is a megaproject? How does it differentiate from a standard project? Which actors influence performances for megaprojects? The qualitative data of nine case studies were collected from a series of different sources (published reports, project reports, journals and news articles) and collated into an Excel spreadsheet for easy reference.

22.3.1 Originality/Value

However, Eisenhardt (1989) advised against adding cases when there is incremental improvement upon reaching theoretical saturation. Small convenience sampling was applied for this study, and therefore no scientific significance obtained; however, a greater sample would be recommended to increase validity.

The study has gone beyond the focus of previous literature highlighting endless listings of causes and cures of MP failures; instead, this paper critically analysed the performance criteria currently used and encouraged a new way of evaluating projects incorporating both internal and external factors especial uncertainty and risks for a more structured assessment when evaluating performance for a more objective success rate.

Based on data analysis, the following hypotheses were derived for future research:

H0 = Variance in time, quality and cost does not confirm if any value has been derived nor if the project has been successful.

H1 = Positive variance (in time, quality and cost) causes a reduction of uncertainty and risks.

H2 = Negative variance (in time, quality and costs) causes an increase of uncertainty and risks.

H3 = Variance relates directly to the phenomena of uncertainty and risk management.

22.3.2 Research Limitations

- Data associated with project outcomes are rich and qualitative, and conversion into a quantitative form is required analysis or interpretation. This process can be disreputably difficult; hence case studies have been limited to only nine cases for this paper.
- Greater sample size will be required to obtain scientific significance.

22.4 Findings

The outcomes of project assessments were firstly based using the iron triplets and then based on a more flexible model/approach (Fig. 22.2). Refer to the next page for an illustration of how a contemporary review on the same factors linked to uncertainty and influenced the overall success rate by 55% for these cases.

It was clear that benefits and outputs of these projects were mostly ignored during evaluations or simply not assigned significant weight. All these projects derived variances, which resulted in failure based on the iron triplets. However, based on the

Case Study	Project Aim	Project Start Date	Project completion	Cost variance	Project assessment (Risk and Uncertainty)	Assessment, Iron Triplets (Cost, Time, Quality) on completion.	Adopted Review	Variance, Details and Analysis
Edinburgh Trams (1)	To improve accessibility, reduce congestion and promote sustainability (Connect Edinburgh Airport to City centre and development areas).	2007	2014	328million	Cost and Time variance caused a rightwards shift increasing uncertainty and risk levels. Whilst a left shift based on (q)variance reduced uncertainty and risk for successful delivery.	**Failed**	CV=IUC+Risk QV=DUC+Risk TV=IUC+Risk **= Success**	Highest customer satisfaction rates in the UK. Overspent, delayed Completed to Specification
Scottish parliament (2)	Building a parliament building for Scotland	1999	2004	414million	An overall increase in uncertainty and risk.	**Failed**	CV= IUC+Risk QV=IUC+Risk TV=IUC+Risk **= Failed**	Claimed to be out of context for the land it represents. Overspend, delays, design Not to specification
NHS information IT (3)	Centralised patients e-record system	2003	2013 - ceased existence	3.6billion	An overall increase in uncertainty and risk.	**Failed**	CV= IUC+Risk QV=IUC+Risk TV=IUC+Risk **= Failed**	By 2013 only 13 trusts received full patient administration information compared to the ordinal 169. Plague with delays, no inhouse system integration, the unreliability of the data, complaints Not to scope
London Eye (4)	Monument to Mark the start of the century	1998	2000	The cost was declared to be 75million higher than normal construction.	Cost variance caused a rightwards shift increasing uncertainty and risk levels. Whilst time and quality variance led to a leftwards shift based on reduced uncertainty and risk for successful delivery.	**Failed**	CV= IUC+Risk QV=DUC+Risk TV=DUC+Risk **= Success**	Highest Tourist Attraction, promising revenue and ROI. Most successful architectural project. to scope specification
London Olympics (5)	Host-Summer Olympic Games	2005	2012	157%	Cost and quality variance caused a rightwards shift increasing uncertainty and risk levels. Whilst a left shift based on (t)variance reduced uncertainty and risk for successful delivery.	**Failed**	CV= IUC+Risk QV=IUC+Risk TV=DUC+Risk **= Success**	A potential source of economic income regeneration No to scope
UK Passport Agency (6)	Provision of passport services to British Nationals in the UK, most economically and promptly.	1991		285million	An overall increase in uncertainty and risk.	**Failed**	CV= IUC+Risk QV=IUC+Risk TV= IUC+Risk **= Failed**	UK customer satisfaction Index currently at 76.9 or 0.8 points at the lowest level since July 2015. Failed
Portsmouth Spinnaker Tower (7)	Designed as a monument to commensurate millennium celebrations.	2001	2005	24.5million	Overall increase in uncertainty and risk.	**Failed**	CV= IUC+Risk QV=IUC+Risk TV=IUC+Risk **= Failed**	Residents had demanded the change of original Arabic design. Over cost, delayed by 5years and not to specifications. No to scope
Channel Tunnel (8)	A railway tunnel connecting England and France.	1988	1994	11.4billion	Cost and Time variance caused a rightwards shift increasing uncertainty and risk levels. Whilst a left shift based on (q)variance reduced uncertainty and risk for successful delivery.	**Failed**	CV= IUC+Risk QV=DUC+Risk TV= IUC+Risk **= Success**	Approximately 80million vehicles, 185million Eurostar passengers, goods valued over, £150bn worth of goods, travelled through this tunnel since 1994, including the Olympic Torch and Tour de France. Cost overrun, delayed schedule The variance from the original scope.
Thames Barrier (9)	A Movable barrier system to prevent floodplain.	1974	1984	0.1billion	Cost and Time variance caused a rightwards shift increasing uncertainty and risk levels. Whilst a left shift based on (q)variance reduced uncertainty and risk for successful delivery.	**Failed**	CV= IUC+Risk QV=DUC+Risk TV=IUC+Risk **= Success**	Closed 186 times since opening to protect Greater London from floods, next review 2030 subject to climate change, but specialist review reckon can be delayed for 40 Completed yrs. The variance from original scope.

Fig. 22.2 Performance data of case studies based on the iron triangle constraints (Chatelier 2020). *V* variance, *C* cost, *Q* quality, *T* time, *UC* uncertainty, *R* risk, *I* increase, *D* decrease

adopted model, variances were considered as interdepend factors for success and not sole determinants. An evaluation was also suggested to be carried out throughout the project life cycle including post project to monitor uncertainty and risk rates for better performance.

22.5 Discussions

22.5.1 The Fallacy of Traditional Project Management Theory

Whilst there are established approaches and guidance made available in the project management domain (BABOK, 2005 and PMI, 2008), they are only acceptable for projects, not megaprojects. Similarly, Mishra et al. (2015) also criticised historic economic techniques used for analysis to construct compatible future cash flows and proposed a framework for addressing uncertainty and risk for TIPs (transport investment projects) for both private and public institutions.

There has been commotion amongst researchers and practitioners that the continuance of project failure problems may be more closely associated with traditional project management (TPM) theory than expected. A well-presented example is critics that TPM centres around the efficiency of outputs based on elements of the iron triangle whilst paying less attention to processes that encourage value or benefit generation (AShurst et al., 2008; Remenyi and Sherwood-Smith, 1998). This paper supports this view; whilst the project environment has evolved over the last 50 years, the principles used to measure performance have stagnated.

Both the analysis of case studies on page 7 and literature demonstrate there is still much controversy regarding the overall evaluation of projects. A clear lack of understanding is evident when practitioners had simply accepted the impossible likelihood of success using the iron triplets whilst disregarding the uncertainty and risks instigated. Authors like Oisen (1971), Barnes (1988) and Weaver (2007) referred to these three factors as 'The iron triangle of project management' because of this strong cohesion in the project management domain.

Several other authors like Baccarini (1999), Cooke-Davies (2002) and Dvir et al. (2003) highlighted the differences between realising success by firstly delivering product specifications (measured against realised benefits of the project) and by secondly successfully managing the project (as per iron triangle constraints). In the context of the latter, a hospital operation can be successful based on the efficiency wrt (with regard to) money spent, but there will be no value derived if the patient does not survive.

The Contemporary Iron Triangle Performance advancing through levels is shown in Fig. 22.3 where the labels "Level 1," "Level 2," etc. are used to characterize uncertainty and risk levels. A project at Level 3 is experiencing high levels of uncertainty and risks (3 or more unknown factors) compared to projects at Level 2 (2xor more unknowns). Each vertex represents the project starting at 0 for the relevant constraint where a variance increase will cause a move to the right side of the triangle and reduction will trigger a move to the left.A variance to the right = increase in uncertainty and risk levels and vice versa.

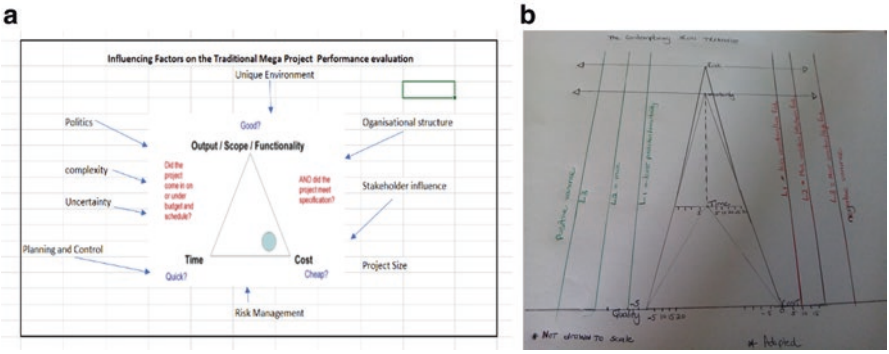

Fig. 22.3 (**a**, **b**) Adopted from iron triangle (Albert, 1969)

The authors of this paper challenge the way megaprojects are being evaluated using the popular 'iron triangle', arguing that the constraints originally shared by Dr. Martin Barnes in 1969 do not reflect the complexity and uncertainty of megaprojects nor the contemporary changing project environments and more specifically cannot be extended for use within the megaproject domain. The use of these constraints is leading misinterpretation of what constitutes success for megaprojects and therefore should be declared obsolete. If not addressed, the issue has the potential to escalate the ambiguity within this dynamic domain where other constraints like stakeholder conflicts, resources levelling and strategic misinterpretation had become major challenges.

22.5.2 Case Study Analysis Based on the Iron Principles (Quality, Time and Costs)

Measuring project performance during its project's life can help deal with scope creep. Dwain Wilcox CIO of Axial Corporations argued 'As we see elements that would contribute to scope creep, we address it in risk management profile because scope creep is affecting the outcome of the project or the budget or resources; it is truly a risk that has to be managed'. He further insisted on classifications to be made by both size and scope for organisations to establish the right tracking and outcomes to pursue. Other researchers also suggested alternatives to quality; most popular interpretation is to replace quality with scope (e.g. Badewi, 2016; van Wyngaard et al., 2012). The paper will, however, retain the original constraints of the iron triangle throughout.

Both the Scottish parliament building and the Portsmouth tower had issues with the original designs which lead to significant time delays. In the case of the Portsmouth's millennium tower meant for residents to celebrate the year 2000, unfortunately, the tower was later renamed as spinnaker due to missing the century

milestone. O'Brien (1998) and Ibbs et al. (2001) consider this as common practice for construction projects, causing not only significant variation to the contract duration (Ibbs et al., 1998) but to cost and scope. Regarding the suggested revised model, both uncertainty and risk had increased for all three factors, and therefore the project has been declared a failure.

In the case of the London eye case review, which serves as a good example of the contradictory argument, this paper posits where the immediate outcome of the project was regarded satisfactory due to early completion of 16 months instead of the expected 24 months. Delivered on the specification but because of the cost overrun, the most popular tourist attraction was deemed a failure according to the iron triplets, though revived now as successful based on the model illustration (Fig. 22.2). Both the quality variance and time variance moving inwards towards the centre line of the triangle (reduction of risk and uncertainty) oppose to cost variance moving outwards, leading to an overall positive outcome. The project outcome will therefore be regarded as successful.

Although one could imagine that the Olympics games unlike other major projects share some likenesses and can learn from predecessors, the cost variance would, therefore, be expected to be much lesser compared to other major projects. On the contrary, the London 2012 summer games case revealed the costs at an astonishing 15.0 billion USD and further proved to be the most expensive to date compared to other games like Beijing (2008) who achieved costings of 50% less and an overall variation of 2% compared to other destinations (Leslie-Carter et al., 2009). But Koch-Weser (2013) dims the spotlight by arguing that China has a reputation for lack of reliable economic reporting. Therefore, it is worth observing that clearly with such high variance percentages, there is no obligation from organisers that they have any intention to comply with the principles of the 'iron triangle'. Because of the mitigated risk of non-deliverance at the sacrifice of cost, the project will still be considered successful as per the above-revised model taking into account the benefits to all athletes, hosts and society outweighing that of the costs sacrificed.

Even though it was found that the Olympics are the most costly megaprojects across all industries with an average cost overrun of 156%, followed by IT at 107%, road constructions are the least at 20%. Mishra et al. (2015) highlight that TIPs (transport investment projects) demand long-term maintenance and commitment due to its irrevocable investments but contribute to both direct and indirect costs (Ibbs et al., 1998). Even though the construction industry had made room for variations in contracts like the NEC3/4, performance indicators for the industry seem to lag. The revised model equally presents a reflection on both opportunities and risks—the Olympics could directly impact FDI and boost the economy.

The Channel Tunnel has been dismissed in literature as a permanent burden to the taxpayer and a definite failure. Poor collaboration between the French and English governments meant engineering works and designs caused major delays for this project. On the contrary, this paper argues that this project has successfully exceeded specifications, mitigating safety risks for all using the channel, at the sacrifice of cost and time. It is worth noting that some of the benefits include the £150bn worth of goods including fresh fruits and veggies being transported yearly,

consequently playing an integral role in trading with Europe; see case analysis for other benefits.

The Edinburgh trams received many critics about ruining the sight and navigation around the city when constructed, but years later obtaining the highest customer satisfaction rates in the UK, another example that the quality output had outweighed the cost and time variance sacrifice for the projects.

All nine projects discussed had initially been condemned as a failure based on the iron triangle constraints, but it has become apparent that when thoroughly evaluated accounting all outputs, uncertainty and risk mitigation of these projects had already delivered positive returns or have the ability to deliver these in the future. A revised success rate of 55% for these projects most definitely inspires hope for the future of megaprojects.

22.5.3 Risk Management in Complexity and Uncertainty

Lock (2003) highlighted 'The principal identifying characteristic of a project is its novelty. It is a step into the unknown, fraught with risk and uncertainty' (Lock, 2003, p. 4). Project management theory tends to 'solve' this dilemma by proposing a risk management process. Franke (1993), who studied the correlation between risk management and project control, suggested the main task of taking control of the project is by reducing ambiguity whilst simultaneously linking risks associated with project delivery. However, the iron triangle theory contradicts the 'problem-solving method' by constraining the participating performance factors; thus more is unknown causing more uncertainty.

Turner and Zolin (2012), supported by Beier and Heathcote (2010), suggested two ways of coping with risk: (1) avoiding the uncertainties where possible or taking the responsibility to investigate the reason for uncertainties and if this could, in turn, become certain or (2) accept the existence of uncertainties and proactively manage them. Not much is explained by Turner on available methodology to turn the 'uncertain' to 'certain'; the author would, therefore, suggest the third as (3) continuous testing, tracking, reviewing, resolving and accepting of new uncertainties as the project environment changes and fourth as (4) maximising opportunities if viably presented by these uncertainties. Many theoretical authors including Paul Roberts (2013) encourage PMs to report on variance escalated but, however, do not provide any guidance on the root cause analysis for variance and corrective action anticipated. By providing an opportunity for risk and uncertainty to be taken into account when evaluations on project successes are completed. It sets a reflective platform which is most convenient and cost-effective for any root cause analysis of variance to be investigated asap. If managed well, it could reduce both uncertainty and complexity. From this perspective, the complexity appears not only as a problem but simultaneously an opportunity where mutual interdependencies would encourage coordination. It was suggested that the inevitable uncertainties in megaprojects could enable harness benefit of reflexivity, adaptability and exploration of alternative pathways (e.g. Gelatt, 1989).

22.5.4 Misinterpretation Justified: Hirschman's Hiding Hand Theory (HHP)

Following the popularity of the iron triangle, many concluded that it was better to brush off the issues—literature was pointing out about the limitations of the iron law, especially for megaprojects. Alfred Hirschman was, however, keen to address these concerns by introducing the Hiding Hand in 1967. He argued that there is a rough balance in megaprojects: a tendency to underestimate the costs and problems of megaprojects, but similarly the tendency to underestimate the creativity with which people address the costs and problems that arise. Flyvbjerg later condemned this view as 'beneficial ignorance' as simply strategic misinterpretation and lack of accountability (2016).

This paper is not joining the parade on project failure rates but, instead, viewing the iron triangle as a didactic device, intended to communicate the relationship between time, cost and other potential criteria; the authors note that the triplet variations in megaprojects are not only interrelated but correlated with other active variables such as uncertainty risks, complexity, the achievability of requirements and the standard to which deliverables are produced.

However, due to the small sample size and research, a generalisation although apparent is not yet concluded until scientific significance is obtained using a larger sample size.

22.6 Summary and Conclusions

This review of the challenges facing megaprojects when evaluating performance finds still struggling with issues identified and at best only partially addressed for practice. The greater complexity and uncertainty that come with size serve to demonstrate the cumulative impact of megaproject management's contemporary issues.

The findings of this paper conclude that firstly the iron triangle should be declared obsolete or at the least adapted to include more relevant factors as illustrated on page 7. Secondly, there is a clear need for an introduction to a new way of evaluating megaprojects in line with their unique characteristics. Based on both literature and practice, the iron triangle certainly does not promote an accurate holistic view of how projects perform. More guidance is therefore needed for megaprojects to perform. Several hypotheses are proposed based on literature and cases presented for the incorporation of how this research develops.

Once the city is known for leading the world in delivering megaprojects, London's risk management's response with regard to the biggest challenge of its lifetime (COVID-19 pandemic) will not go unnoticed. The general assumption is probably relevant to the public service social act stipulating that projects 'might improve the economic, social and environmental well-being of the relevant area' (Public Services (Social Value) Act, 2012, p. 2).

After the pandemic, the demands for risk management will only escalate with existing projects revaluating the need to save cost and be efficient to create more value, and therefore demanding accuracy when evaluating megaprojects has never been more essential. In this climate, there is an absolute urgent call for megaprojects to perform, but for megaprojects to perform, they need to step away from the iron triangle to reduce uncertainty and risk subsequently. To perform is to take a complex series of actions that integrate skills and knowledge to produce a valuable result. The model presented is therefore a stepping stone towards a holistic framework or strategy needed to address the problems faced by project managers in megaprojects. Developing performance is a journey, and the level of performance describes the location in the journey. Attention is drawn to uncertainty and risk management to help deliver meaningful successful projects for a better society and sustainable economies. This paper is, therefore, now declaring the triangle obsolete and any supporting theories including the HHP.

> How wonderful that we have met with a paradox, now we have hope of making progress (Niels Bohr, 1996)

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