

Institution: University of Oxford		
Unit of Assessment: 17 – Business and Management		
Title of case study: Improving Megaproject Performance through Better Decision Making		
Period when the underpinning research was undertaken: 2009-2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Bent Flyvbjerg	Role(s) (e.g. job title): BT Professor and Chair of Major Programme Management	Period(s) employed by submitting HEI: 01/04/2009 – present
Alex Budzier	Fellow in Management Practice in the Field of Information Systems	10/03/2011 – present
Period when the claimed impact occurred: August 2013 - December 2020		
Is this case study continued from a case study submitted in 2014? N		
<p>1. Summary of the impact (indicative maximum 100 words) Research on the theory and methodology of quality control and due diligence in megaproject management carried out by Flyvbjerg and Budzier since 2009 has played a major role in the improved performance of megaprojects around the world. Significant examples include the High Speed 2 and Edinburgh Tram Extension projects in the UK, the Muskrat Falls hydroelectric dam in Canada, and the MTR railway in Hong Kong. Additionally, the researchers' cost and benefit analysis of recent Olympic Games has led many countries to reconsider hosting the Games, with the most high-profile example being the Mayor of Rome publicly citing the research as the reason to withdraw from the 2024 hosting process.</p>		
<p>2. Underpinning research (indicative maximum 500 words) A long-running programme of research on the theory and methodology of quality control and due diligence in megaproject management has been undertaken at Saïd Business School since 2009. [R1] defines megaprojects as large-scale, complex ventures that typically cost USD1,000,000,000 or more (04-2017), take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people's lives. The research identifies a key issue in megaproject management, namely that front-end, ex ante estimates of costs and benefits linked with projects are often significantly different from actual ex post costs and benefits, with substantial cost underestimates combining with equally significant benefit overestimates. They are therefore poor predictors of value and viability and cannot be trusted as the basis for informed decision-making in project planning [R2]. This is a problem because front-end estimates are used in making the business case, cost-benefit analysis, and social and environmental impact assessments supporting the decision whether to advance a project. Resulting cost overruns and benefit shortfalls lead to inefficient allocation of public and private resources. The importance of sound quality control and due diligence procedures at the project planning stage is underscored by the UK government's estimate that 80% of all policies are delivered through large-scale projects and programmes. Meanwhile, global spending on megaprojects is estimated to be between USD6,000,000,000,000 and USD9,000,000,000,000 (04-2014) annually, or 8% of the total global gross domestic product (GDP) [R3].</p> <p>Flyvbjerg and Budzier's research shows that problems identified with cost overruns and benefit shortfalls in the context of transport infrastructure projects [R2, R4] apply equally to a wide range of other project types, including mega-events such as the Olympic Games [R5], Information and Communications Technology (ICT) systems, and energy infrastructure [R1]. The unique size of the datasets gathered since 2009 has enabled empirical comparisons that previously were not possible. [R5] for example establishes a phenomenology of cost and cost overrun at the Olympic Games, which allows for consistent and systematic comparison across Games covering the period 1960-2016. The research finds that the average actual outturn (construction) cost for Summer Games is USD6,000,000,000, and USD3,100,000,000 (09-2020) for Winter Games. At 156% in real terms, the Olympics has the highest average cost overrun of any type of megaproject. Moreover, cost overrun is found in all Games, without exception [R5].</p> <p>Research described in [R6] has contributed to improved decision-making in megaproject planning by developing a new methodology for quality control of front-end estimates, based on</p>		

Kahneman and Tversky's behavioural economic insights of the planning fallacy and the outside view. The research brings the latter's economic theory to bear upon quality control and due diligence in megaproject management by developing an 8-step procedure for systematically and reliably assessing the size of decision-making biases and de-biasing project forecasts based on a reference class of similar projects. Reference Class Forecasting (RCF) methodology thereby replaces subjective judgements of project promoters – vulnerable to optimism bias, political bias, and strategic misrepresentation – with objective empirical data. [R6] provides a case study with empirical test and demonstration of the methodology. Nobel Laureate Kahneman referred to Flyvbjerg's research on the RCF methodology and how to deal with the planning fallacy as, 'the single most important piece of advice regarding how to increase accuracy in forecasting through improved methods,' (*Thinking, Fast and Slow*. Simon Schuster: New York, p. 251).

3. References to the research (indicative maximum of six references)

R1. Flyvbjerg, B. 2017. *The Oxford Handbook of Megaproject Management*. Oxford: OUP. Available on request [output type: B]

R2. Flyvbjerg, B. 2009. Survival of the Unfittest: Why the Worst Infrastructure Gets Built – And What We Can Do about It. *Oxford Review of Economic Policy*, 25(3), 344–367. <https://doi.org/10.1093/oxrep/grp024> [output type: D]

R3. Flyvbjerg, B. 2014. What You Should Know About Megaprojects and Why: An Overview. *Project Management Journal*, 45(2), 6-19. <https://doi.org/10.1002/pmj.21409> [output type: D]

R4. Flyvbjerg, B., Hon, C-K., Fok, W.H. 2016. Reference class forecasting for Hong Kong's major roadworks projects. *Proceedings of the Institution of Civil Engineers: Civil Engineering*, 169(6), 1-8. <https://doi.org/10.1680/jcien.15.00075> [output type: D]

R5. Flyvbjerg, B., Budzier, A., Lunn, D. 2020. Regression to the tail: Why the Olympics blow up. *Environment and Planning A: Economy and Space*. September 2020. <https://doi.org/10.1177/0308518X20958724> [output type: D]

R6. Flyvbjerg, B. 2013. Quality control and due diligence in project management: Getting decisions right by taking the outside view. *International Journal of Project Management*, 31(5), 760-774. <https://doi.org/10.1016/j.ijproman.2012.10.007> [output type: D]

Awards and prizes

[R3] won Project Management Journal Paper of the Year Award 2015 and Emerald Citation of Excellence Award 2017. Flyvbjerg received the European Institute for Advanced Studies in Management Interdisciplinary Leader Award in 2018, recognising his exemplary contribution to interdisciplinary research. He was awarded the 2019 Project Management Institute's Research Achievement Award for having significantly advanced the concepts, knowledge, and practices of project management through a published body of academic research.

4. Details of the impact (indicative maximum 750 words)

Flyvbjerg and Budzier's Reference Class Forecasting (RCF) methodology has been used extensively by governments and practitioners in the UK and internationally as a complement to more traditional quantitative risk assessments in megaproject management.

Impact on UK major projects

In the UK, RCF forms a core part of the Infrastructure and Projects Authority's (IPA) 2016 guidance on risk management [E1] and a special report by the National Auditor. RCF is also used as the method to establish the 'Optimism Bias Uplift' required by HM Treasury's 2018 Green Book, which provides definitive analytical guidance for government on how to appraise policies, programmes, and projects that concern public spending [E2]. Members of the IPA – the government's centre of expertise for infrastructure and major projects – have benefitted from instruction on the RCF methodology at Saïd Business School's Major Projects Leadership Academy. The National Infrastructure Commission (NIC) has used RCF to inform the Government's 2019 consultation on a Regulated Asset Base approach to financing nuclear

power plants [E3a], and in its 2020 study informing the government's Integrated Rail Plan for the Midlands and the North [E3b]. The most high-profile uses of RCF methodology in the assessment period have been High Speed 2 (HS2) and Edinburgh Tram Extension.

Increasing confidence in treatment of risk at Europe's largest infrastructure project

The Department for Transport (DfT) relied on RCF as the most objective means of reviewing adequacy of contingency when setting the Funding Envelope and Target Cost in the Full Business Case (FBC) supporting Phase One main civils construction works for HS2 in April 2020. The Project Management Office Director at HS2 Ltd, responsible for setting the enterprise-wide standard for project management and controls, confirms RCF's influence on the company's approach to risk: *'The Oxford team has been supporting HS2 for 4 years; helping the company to understand how it can apply Reference Class Forecasting to provide a more realistic view of outturn costs, to support more traditional QRA model outputs. This work resulted in several briefings to central Government and increased confidence in stakeholders and sponsors that the HS2 project can deliver and should go ahead.'* [E4a]

Flyvbjerg and Budzier provided the reference class forecast for HS2's FBC using a customised dataset of 526 similar projects. DfT complemented their analysis with HS2 Ltd's Quantitative Cost Risk Assessment (QCRA) to arrive at an overall judgement on the Funding Envelope and Target Cost for delivering Phase One of GBP35-45,000,000,000 (Q3 2019) and GBP40,000,000,000, respectively [E4b]. The interim Head of Risk at HS2 Ltd acknowledges that this work *'is now viewed as the benchmark for the company and the DfT when comparing QRAs against RCFs to inform risk-based decision-making.'* [E4c]

Announcing the project's move from enabling works to full construction in September 2020, HS2 Ltd expected to recruit 22,000 new roles [E4d]. This was in addition to more than 9,000 people already employed, and over 2,000 UK businesses with contracts. RCF's pivotal role in setting a more realistic baseline for the project was a key part of the FBC supporting this outcome. Flyvbjerg and Budzier's engagement with HS2 Ltd continues in 2021, providing route wide RCF services for phases 1, 2a and 2b, together with designing and delivering internal and external stakeholder training on treatment of risk and uncertainty in the project.

Informing contingency planning at Edinburgh Tram Extension

Edinburgh City Council used RCF in 2018 to test and refine its approach to risk before deciding to proceed with construction of the Edinburgh Tram to Newhaven extension. The project completes the originally envisaged Phase 1a of the Edinburgh tram network in Scotland, connecting Leigh and Newhaven to the current end of the Edinburgh tram line. Previously the project team had used Quantitative Risk Analysis (QRA) and government guidance on adjusting for optimism bias to make risk provisions in the form of contingency of GBP43,200,000, representing a 26% uplift on top of the project's base cost estimate of GBP164,100,000, and a total cost estimate of GBP207,300,000. Flyvbjerg and Budzier established a cumulative probability distribution for a selected reference class of 89 completed light rail extension projects, ordering projects by size of overrun and their cumulative share in the sample. Placing the Edinburgh tram extension at an appropriate point in the reference class distribution, they calculated the existing 26% provision for risk was equivalent to a 39% acceptable chance of cost overrun. The Council responded by comparing reference class projects in Flyvbjerg and Budzier's report at 20% chance of overrun (mirroring the base case QRA at probability value P80). This resulted in a revised project cost inclusive of optimism bias of GBP257,600,000, an increase of over GBP50,000,000 on the original estimate. This increased the GBP1,900,000 cashflow challenge for the project to GBP14,800,000, with reserves being repaid by 2037 instead of 2027 [E5b].

Reflecting on Flyvbjerg and Budzier's earlier report to the Edinburgh Tram Inquiry in February 2018 (which referenced [R1-R6]), the Council decided to make contingency plans for the higher project cost of GBP257,600,000. This required a series of measures be implemented to fund or mitigate the risk. The Council investigated options to address the increased cashflow challenge by identifying mitigation measures such as forward borrowing to lower cost of funding, review of

fare strategy for tram, and bringing forward operational efficiencies, including potential savings on tram and infrastructure maintenance [E5a]. The Council undertook capital cost sensitivity testing as part of its assurance process to determine that the project's benefit cost ratio remained positive based on Flyvbjerg and Budzier's optimism bias at probability value P80.

The Project Director of the Edinburgh Tram Extension confirms: *'Prof Flyvbjerg and Dr Budzier provided a reference class forecast for the project, and in discussion with the project team, advised on the application of the reference class forecast... This served a dual purpose. Primarily, it gave confidence that the budget set aside to complete the project was realistic, and secondly, it provided a counterpoint to the standard QRA approach giving a context for discussion on approach to risk in the project more widely.'* [E5b]

The March 2019 FBC economic appraisal estimated net public transport user benefits of over GBP395,000,000 from the project and overall net present value of GBP112,800,000, as well as contributions to wider policy objectives and outcomes for the city in terms of spatial planning, development strategies, and improved accessibility for areas of high deprivation. The project is creating several hundred jobs during its construction phase and once operational is forecast to create an additional 78 jobs rising to 92 by 2032 [E5a]. Flyvbjerg and Budzier's research supported the financial modelling in the FBC that gave the Council confidence to proceed.

International impact on major projects

In Hong Kong, Flyvbjerg and Budzier's research has led to the introduction of an enhanced Environmental and Risk Assessment Stage to government projects. [R4] *'has provided valuable insights into how projects should be planned and how early estimates... can be de-biased to prevent cost overruns and time-to-completion delays using RCF approach. In the past 3 years, the Project Strategy and Governance Office has managed to vet more than 200 projects and saved more than HKD50,000,000,000 (09-2020 - GBP5,070,993,915) project cost by adopting cost-effective design and optimising the contingency allowance,'* according to the Secretary for Development (Works), Development Bureau [E6]. RCF was also used by MTR Corporation Limited in 2017 to deliver the Guangzhou-Shenzhen-Hong Kong Express Rail Link within the project's re-set budget and ahead of its re-planned opening date [E7]. In Australia, RCF has informed policy for the planning of federal transport projects since 2018, and in New Zealand it has led to introduction of procedures for de-biasing estimates through the 'Better Business Cases' initiative of the Treasury. In Ireland, the Department for Public Expenditure and Reform put recommendations to de-bias project estimates into its 2019 Public Spending Code [E8]. Notable examples of the research's international impact in the assessment period are the Muskrat Falls hydroelectric project in Canada, and potential host cities for the Olympics.

Influencing the Government of Newfoundland and Labrador's approach to risk

Flyvbjerg and Budzier's 2018 report for the Commission of Inquiry Respecting the Muskrat Falls Project in Canada drew on [R1], [R3], and [R6] to provide the national and international context for the CAD12,700,000,000 (06-2017 - GBP7,514,792,899) hydroelectric scheme's failure with regards to cost and schedule overrun, as well as identifying root causes of such overruns. Consequently, RCF was recommended by the Commission to prevent such overruns in hydroelectric dam and other capital investment projects in the future. Flyvbjerg provided expert testimony reviewing highlights of the paper at the public hearings of the independent inquiry on 17 September 2018. The final report of the inquiry noted in its conclusions on cost estimates made at time of project sanction that *'estimates were affected by optimism bias, strategic misrepresentation and political bias, as these terms were defined by Professor Bent Flyvbjerg.'* [E9a] The final report made several recommendations in recognition of these issues, including *'recognizing the likelihood of bias in any cost and schedule estimate, government should require the project proponent to provide a range of cost estimates to establish the project's budget, so that government can determine its own risk appetite.'* The Government updated on implementation of the recommendations in 2020, noting *'the Cabinet Committee on Infrastructure will adopt recommendations to current risk assessment methodology for construction of large project [within 6-12 months].'* [E9b]

Informing candidate countries' decisions on whether to host the Olympic Games

[R5], first published as a working paper in 2012, updated in 2016, provided the first authoritative database of cost overrun risks for the Olympic Games. As a result of the research, several potential hosts have reconsidered hosting the Games, including Rome, Oslo, and Hamburg. In a press conference reported in *The Financial Times*, *The Guardian*, and *The Telegraph* on 21 September 2016, the Mayor of Rome referred to a working paper of **[R5]** when she cancelled the city's candidacy for the 2024 Olympics, noting that '*previous host cities such as London have been left with massive cost overruns and huge debts.*' **[E10a]** Similarly, the leader of citizen engagement behind the campaign to stop Boston's bid for the 2024 Olympics referred to Flyvbjerg and Budzier's research showing cost overruns in recent Olympic Games when asked: '*What do you think did the most to convince Bostonians that the Olympics were a bad idea?*' He replied: '*I think the most important talking point we had was around the taxpayer guarantee. The International Olympic Committee requires host cities to sign a contract saying taxpayers will be responsible for cost overruns...it was hard for the public to trust the boosters and ensure there wouldn't be costs to pay in the case of overruns, as there have been in all of the recent Olympics.*' **[E10b]** The Economist has also cited Flyvbjerg and Budzier's research as the reason why Budapest withdrew its bid to host the Games.

5. Sources to corroborate the impact (indicative maximum of 10 references)

E1. IPA., 2016. *Improving Infrastructure Delivery: Project Initiation Routemap*, pp. 8, 21.

E2. HM Treasury 2018. *The Green Book: Central Government Guidance on Appraisal and Evaluation*, p.30.

E3. NIC:

- a) NIC. 2019. *Estimating comparable costs of a nuclear regulated asset base versus a contract for difference financing Model*. October 2019, pp. 10-12, 16-22.
- b) NIC. 2020. *Rail Needs Assessment for the Midlands and the North*. December 2020, p.36.

E4. HS2:

- a) Supporting written statement from Project Management Office Director, HS2 Ltd.
- b) DfT. 2020. *Full Business Case: High Speed 2 Phase One*, April 2020, pp.71, 74-75, 114.
- c) Supporting written statement from Interim Head of Risk, HS2 Ltd.
- d) BBC News article announcing 22,000 'jobs boost' for Britain.

E5. Edinburgh Tram Project:

- a) Edinburgh Council. 2019. *Edinburgh Tram York Place to Newhaven Project. Final Business Case*, February 2019, p.46.
- b) Supporting written statement from Project Director of the Edinburgh Tram Extension.

E6. Supporting written statement from Secretary for Development (Works), Development Bureau, Hong Kong.

E7. Supporting written statement from Engineering Director, MTR Corporation Limited.

E8. Department of Public Expenditure and Reform. 2019. *Public Spending Code: A Guide to Evaluating, Planning and Managing Public Investment*. Investment Projects and Programmes Office, October 2019, pp.32, 64.

E9. Muskrat Fall Project:

- a) Commission of Inquiry Respecting the Muskrat Falls Project. 2020. *Muskrat Falls: A Misguided Project, Volumes 1*. Queen's Printer for Newfoundland and Labrador, 2020, p.53.
- b) Gov. of Newfoundland and Labrador. 2020. *Update on the progress of recommendations from the Commission of Inquiry into the Muskrat Falls Project*, July 2020, p.3,5.

E10. The Olympics:

- a) The Telegraph. *Rome's new mayor cancels bid for 2024 Olympics*. 21 September 2016.
- b) Sims, S. 2017. *How Bostonians Defeated the Olympics*. Bloomberg CityLab, 5 June 2017.