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Cost overruns–helping to define what they really mean

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Abstract

Practitioners and academics often debate about cost overruns, a pivotal part of the iron-triangle that is traditionally used to assess the project management performance. Intuitively, the term “cost overruns” refers to the situation where the actual costs are higher than the original estimates. However, especially in the case of long and complex projects, with several different budgets, significantly affected by scope changes, inflation~~s~~, etc., the assessment of “cost overruns” can still be subject of misunderstanding. This paper addresses this topic by proposing a way to define and assess cost overruns, particularly in the case of long and complex projects (also called megaprojects) and when publicly available information is scattered. This is exemplified using the case of Nuclear Decommissioning Projects and Programmes (NDPs) that are representative of the above-mentioned scenario. Lastly, this paper reflects on the importance of highlighting the existing constraints and the assumptions adopted during the appraisal of cost overruns.

Keywords

Decommissioning, Economics & Finance, Project Management

List of notation

NDPs: Nuclear Decommissioning Projects and Programmes

C_{end} : “final” costs

$C_{initial}$ **:** “initial” costs

Introduction

Practitioners and academics often debate about cost overruns. But what is the actual meaning of "cost overruns"? The answer might seem trivial: a cost overrun refers to the situation where the actual cost is higher than the original estimate. However, especially in the case of megaprojects, this construct can still be hard to define.

Megaprojects are temporary endeavours (i.e. projects) characterized by: large investment commitment, a budget over £1 billion, vast complexity (especially in organizational terms), long planning and construction schedule. Megaprojects are affected by several high level risks and have a long-lasting impact on the economy, the environment, and the society (Ansar et al. 2016; Brookes & Locatelli 2015). Moreover, especially in the case of large and complex projects, the assessment of the cost overruns is hindered by the issue of data availability, reliability and integrity. Indeed, trying to establish cost overruns is a very difficult task both **outside an organisation** (due to the lack of publically available and reliable data), but it is also hard **within an organization,** because (often) no proper targets are set.

Consider the example in Figure 1. If a construction project was estimated to cost £100 after the concept screening phase and £150 after the detailed design phase, but the contract was ultimately awarded after the tendering process at £180 and the final actual cost of the project was £178, are we confident to say that the project is affected by cost overruns? Or: if the project was approved to proceed after the concept screening for £200, the detailed design estimated costs for £230, but the contract was awarded after the tendering process for £180 (at the lowest bid), and the final actual cost were £230, are we confident to say that the project was affected by cost overruns? And, if so, how much was the cost overruns?

This case is comparable to the London Olympics 2012, where the initial estimates made by the Labour Government reached £2.4 billion in 2005 (when London won the bid). These estimates then raised to £9.3 billion, which allowed the Olympic Minister to declare that the project was a "significant achievement" and allowed the Government to issue a report on the Olympics being "under budget", with £476 million of expected savings on the £9.3 billion budget (BBC 2007; MailOnline 2012).

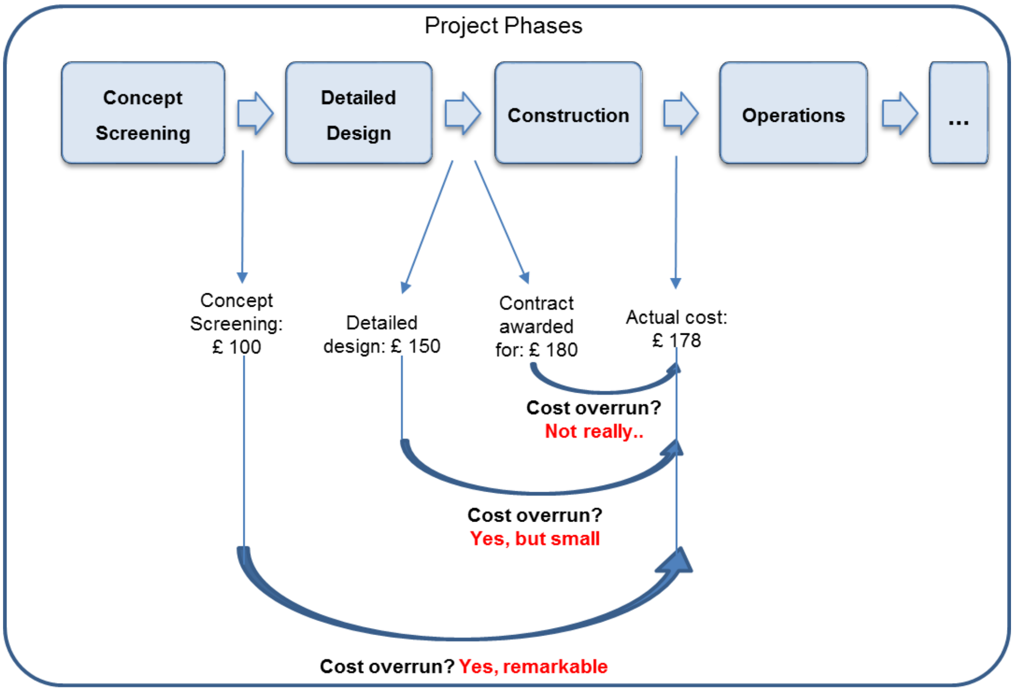

Figure 1. Assessing cost overruns

It may be considered surprising that neither the Project Management Body of Knowledge (2013) nor the Association of Project Management (2016) provide a definition for “cost overruns” or “cost over-budget”, presumably assuming that its meaning is straightforward and its calculation clear. However, this paper argues that, especially in the situations where the development of a project is long and complex (e.g. megaprojects (Locatelli et al. 2014)), the assessment of cost overruns can be challenging.

The authors address this topic by firstly reviewing how cost overruns are calculated in the literature. Secondly proposing a way to assess cost overruns in a rigorous and transparent way, especially in the cases where the number of projects is low and publically available information is scattered, such as megaprojects. This is exemplified using the case of Nuclear Decommissioning Projects (NDPs) that are representative for the above-mentioned scenario. Indeed, since nuclear decommissioning involves the management of radioactive material, NDPs are highly uncertain, complex, and long projects that involve several internal and external stakeholders (Invernizzi et al. 2017). Finally, this paper reflects on the importance of highlighting the assumptions adopted during the appraisal of cost overruns.

The traditional assessment of cost overruns

Cost overruns are traditionally calculated in absolute terms as in Eq 1 and in relative terms as in Eq 2.

Eq 1: $$Cost\ overruns\ [currency] = C_{end}\ [currency] - C_{initial}[currency]$$

Eq 2: $$Cost\ overruns\ [\%] = \frac{C_{end}\ [currency] - C_{initial}\ [currency]}{C_{initial}\ [currency]}$$

Where C_{end} refers to the actual cost, i.e. the costs determined at the time of completing a project and C_{in} refers to the "original estimated" cost. Eq 2 reflects the "Project Cost Growth" metric presented in (CII 2016) and below in Eq 3.

Eq 3: $$Project\ Cost\ Growth = \frac{Actual\ Total\ Project\ Cost - Initial\ Predicted\ Project\ Cost}{Initial\ Predicted\ Project\ Cost}$$

Table 1 provides a review of definitions of cost overruns and of the variables used to calculate it, i.e. C_{end} and $C_{initial}$.

However, even if it is a crucial point, few authors clarify the **project stages** (e.g. the points in time in the lifecycle) and the **sources** to which the figures refer to for the assessment of cost overruns. For instance, if we consider a 10-years project in a country with 3% inflation, the impact of inflation alone would be (1+0.03)^10 = 1.344, which means an impact of 34%. The reference year for "cost estimation" is therefore fundamental to understand if the project is over budget (Lind & Brunes 2015).

Recently, Awojobi & Jenkins (2016, p.21) stated that "*the values for 'estimated' [costs] are based on information documented at the approval stage of the projects, most of which can be found in the Staff Appraisal Reports (SARs) from the World Bank; while the values for 'actual' [costs] are determined by information at the end of construction, following the World Bank's Implementation and Completion Reports (ICRs)".* In 2002, Flyvbjerg et al. (2002, p.5) defined actual costs as the "*real, accounted construction costs determined at the time of project completion*", while estimated costs denoted the budgeted or forecasted construction costs "*at the time of decision to build*"[1].

Ref	Definition of Cost Overruns	Absolute or relative?	C_{end}	$C_{initial}$

[1] "Although the project planning process varies with project type, country, and time, it is typically possible for a given project to identify a specific point in the process as the time of decision to build" (Flyvbjerg et al. 2002)

(Jadhav et al. 2016)	Cost overruns are defined as "*the difference between forecasted and actual construction costs*"	Absolute	C_{end} refers to "*actual costs*"	$C_{initial}$ refers to the "*budgeted amounts*"
(Brookes & Locatelli 2015) and (Locatelli, Invernizzi, et al. 2017)	Projects were judged to be over-budget, i.e. to suffer from cost overruns, when "*the final cost of the project was greater than the 110% of the original estimate (adjusted for the inflation)*"	Relative	C_{end} refers to the costs "*at the point at which the project entered operation*"	$C_{initial}$ refers to the "*estimated costs*", whose figures was taken at the time as close as possible to *"the first formal activity"*, e.g. *"the acquisition of any land rights required for the project"*
(Ansar et al. 2014)	Cost overruns refer to *"actual outturn costs expressed as a ratio of estimated costs*	Relative	C_{end} refers to "*actual outturn costs*"	$C_{initial}$ refers to "*estimated costs", "estimated budget*" and/or "*initial budget"*
(Tokede et al. 2014)	Cost overruns "*insinuate the incongruence of initial estimates with final estimates, after or during the delivery of a project*"	Absolute	C_{end} refers to "*final estimates"* both at the end and during the development of the project	$C_{initial}$ refers to "*initial estimates"*
(Merrow 2011)	Cost overruns are measured as "*the ratio of the actual final costs of the project to the estimate made at the full-funds authorization […]"*	Relative: although not explicit in the definition, cost overruns are calculated as a percentage of the estimated costs	C_{end} refers to the "*the actual final costs"*	$C_{initial}$ refers to the "*estimate made at the full-funds authorization"*
(Cantarelli et al. 2010)	Cost overruns is calculated as *"Actual out-turn costs minus estimated costs as a percentage of estimated costs"*	Relative	C_{end} refers to actual costs, where "*actual costs are defined as real, accounted construction costs determined at the time of project completion",* as in (Flyvbjerg et al. 2002)	$C_{initial}$ refers to estimated costs, where "*estimated costs are defined as budgeted or forecasted construction costs determined at the time of the decision to build",* as in (Flyvbjerg et al. 2002)
(Odeck 2004)	Cost overruns refer to "*Difference between actual and estimated cost*"	Absolute	C_{end} refers to the *"actual cost"*	$C_{initial}$ refers to the "*estimated cost"*
	"*Ratio of actual to estimated cost in %"*	Relative		
(Flyvbjerg et al. 2002) & following, e.g. (Flyvbjerg 2008)	Cost overruns is calculated as *"actual costs minus estimated costs in percent of estimated costs"*	Relative	C_{end} refers to actual costs, where "*actual costs are defined as real, accounted construction costs determined at the time of project completion"*	$C_{initial}$ refers to estimated costs, where "*estimated costs are defined as budgeted or forecasted construction costs determined at the time of the decision to build"*

Table 1. Assessment of cost overruns in the literature

Nevertheless, especially for long projects in the public sector, it is likely that multiple changes occur over time (Flyvbjerg et al. 2002), which affects the definition of "*original estimates*". Cantarelli et al. (2010, p.4), quoting (Cantarelli et al. 2009), highlight that "*the estimated costs at the real decision to build are usually lower than those at later stages of the decision-making process*", which is a situation called "*lock-in*", and that "*references to the formal decision to build do not always provide an accurate picture of cost overruns"* (Cantarelli et al. 2010). Merrow (2011, p.38) defines $C_{initial}$ as the "*estimate* *made at the full-funds authorization"*, and suggests to evaluate cost overruns through (i) a systematic collection of a large number of cases, (ii) the calculation of cost overruns of single projects, and (iii) the definition of a threshold (25%) to determine the actual cost overruns. Tokede et al. (2014, p.19), who describe cost overruns as the incongruence between initial estimates and final estimates, take another step forward specifying that costs can be evaluated "*after or during the delivery of a project".* This shows a remarkable difference with the other publications of Table 1, as the authors argue that cost overruns can be calculated when the **project is not finished yet** but it is still ongoing. Similarly, Locatelli et al. (2016, p.11) define $\mathbf{C_{end}}$ as the "final cost" or as the "*last estimate available for those [projects] still under construction*". Additionally, the CII (2016) emphasizes the importance of mentioning "**according to whom**" the initial estimates are evaluated. This is extremely important, since the iron-triangle was originally adopting the contractor's perspective, and therefore most of the time is not even clear if the values refer to "cost" or "price" (two totally different concepts). Indeed, $\boldsymbol{C_{initial}}$ in the equations Eq 1 and Eq 2 represent for the contractors the cost estimate used as a basis of the contract award, while for the owners $\boldsymbol{C_{initial}}$ refers to the budget at the time of authorization.

In summary, to assess cost overruns, most of the authors:

- rely mostly on the information on completed projects, where both the final costs and the initial estimates "at the time of the decision to build" are also available;
- hardly ever highlight the boundary conditions and the assumptions regarding which point in time $\boldsymbol{C_{end}}$ and $\boldsymbol{C_{initial}}$ refer to;
- give very limited attention to the provenance of the selected values of $\boldsymbol{C_{end}}$ and $\boldsymbol{C_{initial}}$.

Nevertheless, this limits the researches in industrial sectors where:

- projects are particularly long, complex, affected by scope changes and subsequent re-baseline(s);
- the number of completed projects is low; and/or
- the information on these projects is scattered.

In these cases, it is often not clear how to define $\mathbf{C_{end}}$ and $\boldsymbol{C_{initial}}$, and this affects the calculation of cost overruns. The following section recommends a transparent way to define cost overruns.

How to define and assess cost overruns

Cost, time and quality are the three pivotal measures of the so-called “iron-triangle”, traditionally used for assessing the project management constraints. Quality comprises a broad range of topics (safety and security, environmental constraints, socio-economic aspects, stakeholders expectations, etc.) and can be assessed at different points in time and according to a number of different stakeholders involved in the project development (Davis 2014; Turner & Zolin 2012). Time is sometimes argued to be a better indicator project performances than costs, being “more visible”, harder to be manipulated and a driver for cost itself. Nevertheless, as presented in the previous sections, practitioners and academics often debate about cost overruns, which traditionally refers to the situation where the actual costs are higher than the original estimates. Since capital might be hard to find and it does not necessarily have a linear relationship with time, it is important to maintain and investigate cost parameters.

Hence, as the aforementioned studies show that cost overruns can still be hard to define, this research suggests how to transparently assess cost overruns (to eventually and subsequently compare them). This is exemplified using the nuclear decommissioning industry, but the reasoning is similar for other projects and megaprojects.

Nuclear decommissioning consists of all the administrative and technical actions to remove all the regulatory controls from a facility and restore the site to new use (IAEA 2017). Globally, NDPs costs estimates lie in the range of hundreds of billions of pounds, reaching £55 billion in France (WNA 2015) and almost £70 billion in the UK (NDA 2016a). Moreover, NDPs estimates are extremely challenging (Torp & Klakegg 2016) and keep increasing. This is partially due to the fact that the number of the completed NDPs is negligible compared to the new build, therefore there is limited data regarding the cost estimation. Indeed, in the nuclear industry, more than 500 Nuclear Power Plants have been built throughout the 20th century (and still the construction of new units is an enormous challenge), while only 16 have been fully decommissioned (OECD/NEA 2016).

The following points are therefore highly recommended to assess the cost overruns:

- First of all, **clearly state which are the points in time in the project lifecycle, that $C_{initial}$ refers to**. The “original” estimated costs at the start of the project might not be available, or might not even exist. So, it is fundamental to highlight the assumptions underpinning the selection of the point in time that $C_{initial}$ refers to. This is the case of the decommissioning of some nuclear sites, such as Sellafield (UK) (Sellafield Ltd 2016), where the operations of the site are so intertwined with the decommissioning ones that it is extremely hard to draw a line between the two. In this case, these “original” estimates can be defined arbitrarily, but the reasons for this decision have to be clearly stated. For instance, the first publically available information regarding the “original” decommissioning cost estimates for Sellafield dates back to 2005, i.e. when the UK Nuclear Decommissioning Authority was established (NDA 2016b), so these estimates can be taken into account to define Sellafield’s $C_{initial}$.

- Secondly, **clearly state which is the point in time that $\mathrm{C}_{\mathrm{end}}$ refers to**. This can be challenging because the “final” actual costs at the end of the project might not be available, or might not even exist (yet), and it is the case of very long projects that last several decades and/or never reached a conclusion (yet), again as the decommissioning of Sellafield (UK), but also construction projects such as the bridge on the Strait of Messina in Italy (CIOB 2015). The bridge on the Strait of Messina has been a “political debate” in Italy for a generation: a company was set up to build the bridge in the 1980s, and detailed design work was carried out in the 1990s, but the project was cancelled in 2006. Nowadays, this bridge is back on the Italian agenda (CIOB 2015). In these situation, the “final” actual costs are not available, as the projects are not completed yet. However, the Estimate At Completion, i.e. “*the expected total cost of completing all the work expressed as the sum of the actual cost to date and the estimate to complete*” (PMBOK 2013, p.539), can be used instead. This has to be clearly stated in order to define $\mathrm{C}_{\mathrm{end}}$.
- Clearly state **by whom C_{end} and $C_{initial}$ are defined**, being aware of the difference between “cost” and “price” when assessing cost overruns. In fact, one stakeholder’s price is another stakeholder’s cost and talking about “cost overruns” only make sense if the viewpoint of one particular stakeholder is highlighted.

Price is defined as in Eq 4, as a sum of the contractors’ costs plus a mark-up.

Eq 4: $Price = Costs + Markup$

In very simple terms, in a fixed-price contract (known as lump sum contract), the risks are assigned to the contractors, who is expected to request a higher mark-up to tackle uncertainties. In this situation, if the actual costs for the contractors increase and cost overruns occur, the mark-up is eroded (potentially becoming negative, resulting in the contractors’ losses), but the owner is not affected by the cost overruns. Conversely, in a cost-reimbursable contract (known as a cost-plusfee contract), contractors are reimbursed by the owner for the actual cost of performing the work, plus a mark-up. In this situation, if the actual costs for performing the work increase compared to the budgeted ones, the owner is directly affected by the cost overruns as the prices rises. In other cases, stakeholders create a temporary organisation, called Special Purpose Vehicle (Sainati et al. 2015), that further complicates the difference between price and cost.

Moreover, for major and mega projects, estimates are made summing up sub-projects cost estimates. These sub-projects cost estimates refer to the price that will be paid to the contractors (and not the actual costs of the work to be done). This price is normally higher than the cost of work to guarantee a mark-up for the contractors. However, it may be lower for strategic reasons, e.g. to gain the first-mover advantage, or when the actual profit is not made by the selling of the product itself, but of the products and services that the client will need after having bought the first item.

This works both for "smaller projects", such as printer cartridges for printers, coffee capsules for coffee machines, and more significant ones, such as uranium for refuelling nuclear power plants. On the latter topic, Anne Lauvergeon (CEO of Areva - a French multinational group specializing in nuclear power and renewable energy, for ten years) stated in 2008 that the model of the CEA, a French public government-funded research organisation was indeed following the model of coffee machines and coffee capsules (Challenges 2008).

Therefore, it is pivotal to clarify "according to whom" C_{end} and $C_{initial}$ are defined.

- Highlight **to which stage of the development of the project** the estimates refer to (e.g. concept screening, detailed design, etc.) and which is the degree of uncertainty associated to it, as different project stages present different uncertainty levels (GIF 2007) and P50 estimates are significantly different than P80 estimates (UK Government 2015).

  Some uncertainties are caused by known unknowns, so they cannot be dealt with upfront. Others can be mitigated at an early stage of the project development, such as the specification employed at the procurement stage to share the risk of delays in the supply of equipment and services. For example, in the comparison between two NDPs, Sellafield (UK) and Rocky Flats (US) (Invernizzi et al. 2017), it is highlighted that the sharing of responsibility between the US Government and the contractors (in an agreement called "government-furnished equipment and services") helped to avoid delays in the delivery of products or services (Cameron & Lavine 2006) and ultimately avoid cost overruns.

- **Investigate scope change(s) and eventual re-baseline(s),** highlighting the different contractual agreements, which can influence the project performance (Suprapto et al. 2016).

  Scope changes refers to any change to the project scope, and almost always requires an adjustment to the project cost or schedule; scope creep is the uncontrolled expansion to product or project scope without adjustments to time, cost, and resources (PMBOK 2013). So, when scope creep occurs, the additional costs are mostly sustained by the contractor who might have a limited understanding and visibility of the overall economic impact of accommodating all the clients' requirements.

  On the other hand, scope changes are dealt with in different ways depending on the type of contract agreements: in fixed-price contracts, changes in scope are accommodated generally with an increase of the contract price, while in cost-reimbursable contracts, the client has the flexibility to re-direct the contractors whenever the scope of work could not have been precisely defined at the beginning (PMBOK 2013) . This means that, if scope changes are agreed by both parties under a reimbursable contract, scope changes change the "original estimates" and costs are re-baselined, without causing an increase of the cost overruns, but "only" an increase of the overall project cost.

  Moreover, Lind & Brunes (2015) have also summarized the causes of scope changes (i.e. changes in the design, in the production function, in the price of the factors of production, and due to inefficiencies), highlighting the importance of clustering them according to the different phases of the project development in which they occur and the cost overruns that they cause. Unforeseen ground conditions are also source of dispute (Fender-Allison & Mcewen 2017; Clarke 2015).

  In summary, it has to be emphasized to which re-baseline $\boldsymbol{C_{initial}}$ refers to when calculating the cost overruns, and the assumptions that underpin the selection of this particular point in time. For example, in the nuclear industry, scope changes might be trigger by external events that cause changes in the regulations (e.g. like the ones triggered by the Fukushima accident).

- Lastly, clearly state the **financial assumptions** for the assessment of the cost overruns. In fact, inflation, discount factors to model the cost of financing the business activities, assumptions regarding the currency and fluctuations in the rate exchanges can affect the costs significantly.

Again, taking the example of decommissioning, the OECD/NEA (2010, p.58) affirm that "*a one-half percent change in either inflation/escalation or discount rate has a far greater effect on long-term costs than any single cost driver*".

Addressing these points would enable the clear definition of C_{end} and $\boldsymbol{C_{initial}}$ and therefore allow a transparent assessment of the cost overruns**.**

Conclusion

Cost overruns have always drawn the attention of both practitioners and academics. However, particularly in the case where projects are long, complex, affected by scope change(s) and subsequent re-baseline(s), the assessment and comparison of cost overruns can still be extremely challenging. This paper stems from the established literature and presents a way to address these challenges to assess the cost overruns. In particular, it is envisaged to clearly state the assumptions concerning the point in time that C_{end} and C_{in} refer to, the point of view that is adopted (cost overruns - according to whom?), the scope changes and the financial aspects. This enables the transparent and rigours assessment of the cost overruns, which is particularly important in the case of major and megaprojects.

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