1. Introduction

Many IT projects are considered as failures, and IT project failure is often associated with overspending. According to recent research almost one in five IT projects spend 4.5 times the original budget (Flyvbjerg & Gardner, 2023). Why are such failing IT projects not terminated before completion? And is there more to IT project failure than cost performance?

According to some estimates, $81bn was spent in 1995 on cancelled software projects in the US alone (Standish, 2014), in the EU in 2004, €142bn was written off on failed IT projects (McManus & Wood-Harper, 2008). IT project failure is a significant problem, and worth investigating. Such investigations have potential for improving the skills of individuals, the performance of organisations (Fortune & Peters, 1995), and the performance of the industry as a whole (Kerth, 2001; Kusek et al., 2013).

It is not a new idea that we should study project failure to improve future project performance (Abdel-Hamid & Madnick, 1990; Boddie, 1987; Chua, 2009; Collier, DeMarco, & Fearey, 1996; Dalcher, 1994; Dalcher, 2010; Flyvbjerg, 2006; Fortune & Peters, 1995; Fortune & Peters, 2005; Gauld, 2007; Gilbreath, 1986; Hughes et al., 2016; Johnson, 1995; Kerth, 2001; Kusek et al., 2013; Nelson, 2008; Sauser, Reilly, & Shenhar, 2009). Knowledge about the characteristics of past IT project failure is helpful for efforts to prevent future IT project failures. If knowledge about past project failures is ignored, circumstances leading to past project failures are likely to reincarnate as risks in future IT projects. In the field of aviation, for example, investigations of accidents have led to better overall aviation safety. “Independently advancing transportation safety” (NTSB, 2016b), is the mission statement of the US National Transportation Safety Board, and the NTSB “determines the probable cause of the accidents and issues safety recommendations aimed at preventing future accidents” (NTSB, 2016a). The idea of drawing on experience from aviation in the study of information systems failure dates back to the 1980’s (Wise & Debons, 1987).

The IT projects in focus in this paper are run-of-the-mill commercial IT projects as unique endeavours performed by temporary organisations to provide services or products, achieve objectives (PMI, 2017), and provide benefits (Holgeid et al., 2021). Such projects may be contracted or delivered by internal resources on quasi-commercial terms, and delivered by plan-driven or agile approaches (Sommerville, 2016).

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The cases studied in this work are Danish government IT projects, where benefits by stipulation fall into two categories: Efficiency improvements or quality improvements. Even given the focus in this paper on commercial IT projects, there is more to be said about project failure criteria than economic performance, as the literature shows. Furthermore, we shall argue that economic project performance should be evaluated differently before commitment-to-build than after. This is relevant for IT project termination, as can be explained by the marginal cost trap mechanism presented in this paper.

But to avoid misunderstandings in investigations of IT project failure, we must first establish the...
We have conducted the following steps to answer the question, we have first performed a critical literature review and analysis. Subsequently, we have tested the quality of the resulting definition of IT project failure, for example project termination. Current explanations of why failed projects are not always terminated rely on escalation of commitment from behavioural psychology (Flyvbjerg, 2021; Keil et al., 2000; St阶段, 2011). In this paper, we present a new, different, complementary, and less sophisticated theory of project termination based purely on IT project performance: The marginal cost trap. This is significant because the marginal cost trap is simple to apply in a project management context.

2. Research Methodology

The main questions addressed in this paper are: How should we conceptualise and define IT project failure in a way that investigating IT project failure in order to prevent future IT project failures? or simply: What is IT project failure? To answer this question, we have first performed a critical literature review and content analysis. Subsequently, we have tested the quality of the resulting definition of IT project failure by applying a number of cases and additionally asked: Why are some failed projects terminated, others not?

We have conducted the following steps to answer the two questions:

1. Critically reviewed the literature (Boell & Cecez-Kecmanovic, 2014) that explicitly defines or describes IT project failure.
2. Analysed the above literature, made selections and necessary adaptations considering a) the unit of analysis (the project, see below) and b) the type of IT project in focus (run-of-the-mill commercial IT projects) in order to develop a definition of IT project failure in terms of a set of performance criteria that stakeholders associate with IT project failure synthesised from the literature.
3. Studied a small number of cases of failed IT projects.

- failed major government IT projects in Denmark from 2012 to 2015 - to validate the new definition of IT project failure. The validation consisted in qualitatively matching the criteria of the new definition of IT project failure with the characteristics of the empirical cases, including termination.
4. Developed a theory of IT project termination leveraging the new definition of IT project failure, and validated it by plausibility probing case studies of failed government IT projects (Collier, 2006; George & Bennett, 2005; Levy, 2008; Lipton, 2001) based on publicly available sources and thousands of internal project documents uniquely made available by Danish government agencies.

The methodology of the paper is consistent with the epistemological and ontological commitments of critical realism (Bhaskar, 2008; Bhaskar & Hartwig, 2016; Carlsson, 2011; Hoddby, 2019; Mingers, 2000, 2006; Moradi, Kähkönen, & Wynn, 2013; Wynn Jr & Williams, 2012). The literature review method followed is consistent with the iterative approach of database search combined with “snowballing” of Boell and Cecez-Kecmanovic (2014) rather than the comprehensive literature reviews already available in the example literature and define project failure as the failure to deliver outputs that are not fit for purpose (functionality), and project management failure corresponds to the project within the constraints of scope, time, cost, quality, resource, and risk as approved between the project managers and senior management.” (PMI, 2013). This view of project success takes project changes into account by making success relative to “the last baselines approved by the authorized stakeholder” (PMI, 2013). A different view is that the original budget is the point of reference (Budzier, 2014; Cole, 1995; Ewusi-Mensah, 2003; Flyvbjerg et al., 2018; Glass, 1998; Standish, 1995). These two views on the budget criterion for project performance are obviously different, unless they are bridged by adequate contingency provisions built into original plans.

A closer look at proponents of the triple-constraint criterion reveals varying degrees of forgiveness in the distinction between success and failure. Some authors allow a grace margin, for example cost overruns of 30% (Cole, 1995), 50% (Jones, 1995), or 100% (Glass, 1998), whereas PMI sensibly implies that changes and plan deviations should be absorbed by revisions of the plan baseline.

Some authors make a distinction between on the one hand project failure, and on the other hand project management failure, or between process and correspondence failure (Dalcher, 2014; Fortune & Peters, 1995; Lytyinen & Hirschheim, 1987). Project failure means delivering outputs that are not fit for purpose (functionality), and project management failure means failure to produce the planned outputs within predefined constraints, e.g., budget and schedule.

This division represents a clear separation between design and construction, which to some academics, including Morris (2013 and personal communication), is fundamental to project management.
can most often be expressed simply as a shortfall between performance and standards." By evaluating performance against "standards", rather than plans, Fortune and Bignell's concept of failure takes into consideration that plans and "standards" (what the plans should be) may differ. Gilbreath (1996) makes a similar point. Fortune and Peters (1995) also offer an interesting classification of failure types in general: 1) objectives not met, 2) undesirable side effects, 3) designed failures, as for example a fuse that is designed to fail in order to protect people or equipment, and 4) inappropriate objectives. The idea of "inappropriate objectives" covers the problem of "building the wrong thing", and the idea of "undesirable side effects" offers another expansion of the triple constraints view of failure as for example Morris and Hough (1987). Morris and Hough's considerations of secondary stakeholders (Morris & Hough, 1987). "Designed failures" may be understood as predefined exit criteria.

3. The anatomy of project failure and success

Morris and Hough (1987) presented early on a comprehensive framework for understanding failure and success:

“Morris and Hough were among the first to develop a comprehensive framework for understanding failure at the front-end. (Morris & Hough, 1987). Projects may be "terminated on ill-conceived grounds when really they should be allowed to proceed." (Morris & Hough, 1987).

To Morris and Hough, a project may thus fail even if it is delivered in budget, to schedule and to technical specification, but fails for functionality reasons from the sponsor’s, or even secondary stakeholders’ point of view (Morris & Hough, 1987). On the other hand, a project that exceeds budget and schedule will not necessarily be considered a failure. The Concorde is an example of such a project (Morris & Hough, 1987). The construction of the Denver International Airport, and the Channel Tunnel are other examples (Kerzner, 2014b). On the other hand, [...] many projects go ahead which, while having been terminated [...] (Morris & Hough, 1987). In Sauer's words: [...] systems can have all kinds of adverse outcomes yet not be described as failures. Systems can be delivered late, at inflated cost, with inadequate functionality, and may be largely unused, all without necessarily being failures. So long as the project organisation can command the resources and power to sustain its system, it will not be counted a failure because it is serving some organisational purposes. (Sauer, 1993).

Kerzner notes that "project failure is not necessarily the opposite of project success", and that failure and success come in shades of grey (Kerzner, 2014b). Sauer (1993, 1999) pointed out that the success and failure are used as evaluative terms about projects, implicitly making success and failure ex-post determinations. Additionally, projects may fail in some respects and succeed in others. Kuske points to another problem in viewing success and failure as complementary categories of the same domain by noting that success is a state, whereas failure is an event (Kuske et al., 2013). Kerzner further makes a distinction between "pre-implementation failure and post-implementation failure" (2014b), by which he means failure to deliver the expected project outputs (pre-implementation failure) and failure to deliver the expected outcomes (results, or benefits) from using the outputs in operation (post-implementation failure). PMI updated their text on project success in 2017: "Traditionally, the project management metrics of time, cost, scope and quality have been the most important factors in defining the success of a project. More recently, practitioners and scholars have determined that project success should also be measured with consideration toward achievement of the project objectives." (PMI, 2017).

Other research has highlighted the importance of critical activities at the front-end of projects (Dwivedi et al., 2015a; Dwivedi et al., 2015b; Edkins et al., 2013; Glass, 1999; Hall, Holt, & Purchase, 2003; Morris, 2011; Morris, 2009; Morris & Gerald, 2011; Moritz & Elliott, 2011; Moritz & Volden, 2016; Sauer et al., 2009; Serrador & Pinto, 2015; Williams & Samset, 2010; Williams, Samset, & Sunnevåg, 2009). The consequence the emphasis on front-end activities must be the possibility of preconstruction failure, or failure at the front-end.

3.4 Project failure as expectation failure

Lyytinen (1988); Lyytinen and Hirschheim (1987) claim that prior to their survey of the empirical literature on IT project failure, there had been "inauthentic conceptual clarity of the IS failure notion" (Lyytinen, 1988), and that the notion of success was similarly "nebulous". Their study classifies IT project failure in four categories: 1) correspondence failure, i.e., failure to meet project objectives; 2) process failure, i.e., failure to realise objectives within budget; 3) interaction failure, i.e., failure of the system to be used extensively enough by the intended users, and 4) expectation failure, i.e., failure to meet the expectations of stakeholders.

Expectation failure was Lyttinen and Hirschheim's proposal for a general definition of project failure, and it is in line with Bignell and Fortune (1984). Gilbreath (1986) reached a similar conclusion when defining project failure as unmet, reasonable expectation, and in endorsing failure as perception. Gilbreath further proposes to view this perceived failure as the "sum" of what he calls "actual failure" and "planning failure". This highlights that perceived failure may originate both in planning and in execution.

Sauer is critical of both the triple constraint view of failure and the expectation notion of failure (Sauer, 1993). Sauer maintains that there are more reasonable notions (as does Gilbreath) and that it is sometimes by design that projects disappoint some stakeholders' expectations, and finally that some stakeholders are more powerful than others. Sauer's own view is that: "[T]ermination or abandonment is a necessary but not sufficient condition for failure" (Sauer, 1993). This commits Sauer to the view that a project is not a failure as long as the project organisation is sustained. But there seems to be a problem here, at least from a project sponsor perspective, because it would mean that no running project could be evaluated as a failure, regardless of cost, user-satisfaction, achievement of objectives or other such criteria of failure. As Gilbreath remarks: "Some corporations drag the corpse of a project around long after it has lost viability" (Gilbreath, 1986). However, by pointing to failure as an evaluative term, Sauer's analysis highlights that it may be non-trivial, or maybe impossible, to assess a project definitively as a failure before it has ended, for example when the IT system produced by the project has been taken out of operation. Furthermore, Sauer's notion of project failure has the desirable feature of objectivity, i.e., it can be used to distinguish non-failure with minimal interpretational contribution. Sauer is critical of Lyytinen and Hirschheim's notion of expectation failure, and he considers his own account "more forgiving" than expectation failure. But Sauer's account also makes failure contingent on stakeholder evaluations, and actions, so that on this view, there seems to be no fundamental conflict between Sauer's view and the view of failure as expectation failure. It is doubtlessly a useful and...
informative insight that failing to meet stakeholder expecta-
tions may lead to project failure, and that various stakeholders may have varying criteria for success and failure. But expectation failure, as the fundamental concept of failure may be critiqued from a different angle: Can we imagine projects that fail to meet the expectations of all stakeholders, but still deliver higher value compared to alternatives, and therefore are accepted to continue? Such projects may not be formally evaluated as unconditional successes, but it would be equally wrong to necessarily evaluate them as complete failures. This is right, and if we want a notion of project failure that additionally contains a criterion for project termination, then here is a real problem for the expectation failure concept. Since we want to study project failure to prevent it in the future, we want a concept that can point out project failure, so that it might support efforts to recognise symptoms of failure before failure occurs, and preferably in time to prevent it, so that we can design the projects at the front-end in such a way that they have lower risk of failure. Some authors note that a notion of failure based on stakeholder expectations makes failure a subjective rather than objective determination (Davis, 2014; Turner, 1999). We should probably take it that “subjective” here means contingent on a set of criteria particular to a given stakeholder group. But a more important question may be whether the stakeholders’ expectations are legitimate and reasonable. If they are, they should at least in theory be predictable, and therefore it should be possible to have such expectations reflected in the objectives or constraints of the project. It should further be observed that stakeholder expectations are not entirely exogenous fac-
tors for the project; stakeholder management is generally appreciated as a project management activity concerned with both influencing and possibly adapting to stakeholder expectations. One important stakeholder group, not often mentioned, is software developers. An interesting study by Linberg (Glass, 1989; Linberg, 1999) claims that software developers have criteria for project failure that are completely separated from the triple constraint and independent of whether projects are completed or abandoned. Success from software developers’ point of view has to do with the value of their own learning experience, according to Linberg. The fact that stakeholders and project participants have different interests and preferences makes leading and managing projects no different from leading and managing any other organisation or business undertaking. If interests and preferences are irreconcilable, it may indeed be toxic for a project, and misalignment of expectations should be addressed by proper stakeholder management and people management within the project. But the fact that views and interests differ should not in itself prevent the realisation of positive results in professional environments.

The idea of expectation failure is an important insight highlighting that failing to meet expectations that are not formal requirements, or even unknown ex ante, may be a source of attribution of project failure.

3.5 Termination as project failure
According to Pinto and Mantel project failure “usually refers to a project that is terminated prior to completion.” (Pinto & Mantel, 1999). To Evwur-Mensah (2003) an abandoned project is a failed project. The Standish Group use the term impaired about projects that are eventually terminated. Boehm, like Sauer, finds that software project termination does not always imply failure: “[n]either a rapid change, a lot of software projects are properly started, well managed, and properly terminated before completion because their original assumptions have changed” (Boehm, 2000). Boehm’s view seems particularly relevant, if the changes of fundamental original assumptions could not have been foreseen at the time of project planning, or if we are dealing with an experiment rather than a project.

We find it difficult to imagine situations, and we know of no empirical cases where termination before completion of a run-of-the-mill commercial IT project - the focus of this paper - would not be considered a failure from an owner and sponsor perspective (Turner & Zolin, 2012), given that we take the project as unit of analysis. Terminating an IT project “Turner is, however, supportive of Morris’ and Hough’s measures of success (personal correspondence with Rodney Turner, August 2016), may still be the right thing to do, for example from a portfolio point of view, or because the sponsor wants to cut losses, or because a better way forward has been discovered. It is an easy concession to make that termination not always implies failure. But more importantly, the final definitive determination of a project as a success or failure is an ex-post evaluation that may consider unforeseen aspects of the project as a unique endeavour. What we are after here are the project performance criteria that are generally associated with ex-post attributions of IT projects as failures. Termination is not the only relevant criterion for project failure, but it is appealingly objective, in the sense that it can be determined ex post without interpretation whether or not a project has been terminated. Furthermore, taking the owner and sponsor perspective and the focus on run-of-the-mill commercial IT projects is clearly a matter of contextual choice, and other perspectives are, of course, legitimate. For example the perspectives of the end-user, project manager and contracting office (Dvir, Raz, & Shenhar, 2003), or the perspective of the software developer (Linberg, 1999). 4. Critical Review of Recent Literature on IT Project Failure and Gaps
The discussion of IT project performance criteria associated with ex-post attributions of failure can be traced back to 1870s, and it has not yet converged towards any generally agreed upon definition or unifying principle, that is a gap in the literature.

The developments since 2010 in the research on IT project failure and success include Dalcher’s (2014a) proposed distinctions of levels of success. Like Bannermann’s (2008) ideas of multiple levels of success: Process, project management, product, business and strategic, these developments can be traced back to the time of project management (Shenhar & Dvir, 2007) and Morris and Hough (1987). Pankratz and Basten (2013) have independently arrived at a concept of project failure that is strikingly similar to the dimensions presented by Morris and Hough (1987).

Serrador and Turner (2015) found an interesting correlation between “project efficiency” - roughly performance against the triple constraint of budget, schedule and functionality (Cooke-Davies, 2002; Shenhar & Dvir, 2007) - and overall project success as perceived by stakeholders, which may bring back prominence to the classic performance criteria of the triple constraint. On the other hand, a comprehensive literature study on IT/IS project failure by Hughes et al. (2016) cautions against “failing to include any stakeholder aspects.”

Moradi et al. (2020) have conducted an updated comprehensive liter- ature study of project performance criteria, but with a focus on project success. Baghizadeh et al. (2020) assess the literature on IT project failure, or more specifically the literature on information systems development project failure, which they divide in three major perspectives: rationalist, process and narrative. Baghizadeh, Czeck-Kemanovic and Schlagwey acknowledge the literature’s contributions to knowledge of IT project failure, and they do not propose new definitions of project failure. This is a criticism of the end-state focus of IT project failure research and propose a shift of focus “towards [information systems development] distress and the problematic situations experienced during [information systems development] projects.” (Baghizadeh et al., 2020).

This is a constructive proposal for extending the research agenda, and one that would also benefit from a clearer conceptualisation of the end-state to be avoided: the attribution of project failure, which is still lacking in the literature.

For our purposes, we find that strictly identifying IT project failure with termination is too restrictive, because a) we can easily imagine non-terminated projects that project owners will attribute with the classification of some degree of failure, and b) clearly not all failed projects are terminated (Gilbreath, 1986; Sauer, 1993). The appealing idea of reducing all relevant project performance criteria to a matter of expectations may be possible, but we find it - for our purposes - not informative enough to reduce for example the triple constraint and functionality to a matter of expectations. We therefore prefer to build on Morris & Hough’s (1987) small set of “dimensions” of project failure. To avoid the confusion of performance in neutral terms (e.g., budget or schedule performance) with ex post value judgments, in casu “failure”, we prefer to view the updated Morris & Hough “dimensions” not as failure criteria, but as performance criteria associated with stakeholders’ attribution of “failure” to IT projects.

The gaps in the research literature thus remain: a) how should we define IT project failure in a comprehensive and authoritative way for run-of-the-mill commercial IT projects for the benefit of research and practice? b) how do we conceptualise “failure” in IT projects? and c) why are failing IT projects not always terminated?

5. IT Project Failure, the Investment View
In this paper, we follow Morris (2013) in making the project the unit of analysis. We take the owner and sponsor point
of view as main perspective, we take the operations phase into account, where the project can generate benefits, and we focus on run-of-the-mill commercial IT projects. The Danish Government projects that we use as cases are explicitly expected to bring benefits in terms of efficiency improvements or quality improvements. In other words, we look upon the IT project as an investment. We treat project termination as a special case, since it can be determined objectively (i.e., with minimal interpretation) ex post if a project has been terminated or not. Furthermore, unlike other project performance criteria, e.g., budget performance, termination is a black and white distinction. In this section we present:

1. A set of performance criteria that stakeholders recurrently associated with the ex-post attribution of “failure” to IT projects of the type in focus in this paper.
2. A description of circumstances recurrently associated with project owners’ decision to terminate IT projects of the type in focus in this paper, and
3. A theory of IT project termination and the marginal cost trap mechanism that shows why the economic rationale for launching an IT project is different from the rationale for continuing an ongoing project.

### 5.1 IT project performance criteria associated with failure

We believe that the set of criteria presented in table 1 is comprehensive with respect to the triple-constraints views of project failure, Morris and Hough’s dimensions of project success, expectation failure, and that it can be used in a way that is consistent with Pinto, Sauer, and Ewusi-Mensah’s views of project failure that is contingent on termination. The proposed set of criteria is also consistent with contemporary definitions of project failure in the research literature, for example De Bruyne et al. (2021).

#### Table 1: Performance criteria associated with IT project failure

<table>
<thead>
<tr>
<th>Project performance criteria associated with attribution of IT project failure</th>
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<tbody>
<tr>
<td>Shortfall of (one or more) performance criteria:</td>
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<tr>
<td>1. Benefits, financial or non-financial</td>
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<tr>
<td>2. Functionality (in use)</td>
</tr>
<tr>
<td>3. Meeting stakeholder expectations</td>
</tr>
<tr>
<td>4. Meeting triple constraints:</td>
</tr>
<tr>
<td>a) Budget</td>
</tr>
<tr>
<td>b) Schedule</td>
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<tr>
<td>c) Scope of delivery (content and quality)</td>
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<tr>
<td>5. Contractor long term profitability</td>
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<tr>
<td>6. Management of termination</td>
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The criteria one through six are based on Morris and Hough’s “Dimensions of project success” (1987). Criteria one through three are included in Morris and Hough’s original first dimension (1987), and criterion one is more explicit in Morris’ later work (2013). We propose that shortfalls with respect to these criteria, or dimensions, of project performance comprehensively define how owners and sponsors are likely to evaluate the kind of IT projects in focus in this paper as project failures. This set of criteria therefore has predictive potential.

#### 5.2 IT project termination

Why do sponsors not always terminate projects that fail, i.e., fall short of their objectives and constraints? An economically rational sponsor or owner would be expected to take an investment view, and require of an IT project that:

1. The benefits (financial or non-financial, long or short term) of the project are worth the cost of the project, and that
2. The project can deliver the benefits more cost-effectively than alternatives.

This is a general principle for e.g., government programs (Schuck, 2015). Additionally, it finds support in Turner’s theory of projects (Kuska & Howell, 2002; Turner, 2014), which states that the role of scope management is to ensure that: 1) “an adequate or sufficient amount of work is done”, 2) “unnecessary work is not done”, 3) “the work that is done delivers the stated business purpose”.

Sponsors allocate funding for IT projects to invest in expected beneficial outcomes (Holteid et al., 2021; Morris, 2009). Benefits may or may not be measurable in purely financial terms, and in some cases benefits may be for example aesthetic, quality of life, or originate in political choice (Ackerman, 2004). Quantifiable or not, sponsors invest resources in projects in order to achieve benefits, so what is needed from a sponsor perspective is an idea of termination that has to do with the value of benefits, or outcomes (Morris, 2013).

Already incurred project cost in commercial IT projects are generally non-recoverable, in other words, sunk cost. This is because of a) the uniqueness of projects - unfinished customer specific IT project outputs are generally not re-deployable elsewhere - and b) the normally negligible cost of dismantling IT projects.

This means that in an ongoing project the value of expected benefits must justify the cost to complete the project rather than the total cost of the project. This shows that the rationale behind evaluating economic project performance is different before than after commitment-to-build. Before commitment-to-build, economic project performance should be evaluated based on expected total cost. After commitment-to-build, economic project performance should be evaluated based on marginal cost, when considering termination, redefinition, or revision of baseline.

According to the investment view, which in our view follows from taking the project sponsor perspective, IT project termination may thus be associated with the situation where the value of completing the project is negative or unfavourable, see table 2.

#### Table 2: IT project termination - general criterion

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<tr>
<th>IT project termination - general criterion</th>
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<tbody>
<tr>
<td>The value of benefits (quantifiable or non-quantifiable) does not justify the cost to complete the project, or a more cost-effective alternative is available.</td>
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</table>

Value of benefits may be financial or non-financial. In cases where benefits are un-quantifiable, the logic still applies: Sponsors may have accepted a project that promises non-quantifiable value V at cost C for some satisfying or strategic consideration. It does not follow, however, that sponsors can be expected to accept V at a cost of V + c > 1.

Furthermore, increased cost may tip the balance in favour of alternative investments for providing V, hence the relevance of the cost-effectiveness consideration. Constraints may include legal, technical feasibility, organisational, financial, policy, and ethical constraints. Relevant alternatives may include project termination, redefining or replanning the project. Using this compound performance criterion associated with attribution of failure, we will distinguish between the following:

1. **IT project performance shortfalls**: The project is completed, but has shortfalls with respect to benefits, functionality, stakeholder expectations, triple constraints, long term contractor profitability and or management of termination. The concern for contractor profitability in project management may seem at odds with the owner perspective from a narrow shareholder value point of view. Less so, from the perspective of socially responsible owners. More generally, projects may consume resources that are not included in project accounts, e.g., contractor cost. Similarly, projects may produce benefits beyond what is considered in the scope of the project itself. From a global point of view, such extra resource consumption and benefits should ideally be taken into consideration. This may, however, be unrealistic from a practical point of view.

2. **IT project termination**: The project is terminated because the expected value of benefits does not justify the cost to complete the project, or because more cost-effective alternatives are available.

This concept of IT project termination is a theoretical (Sutton & Staw, 1995; Weick, 1995) and normative notion, in the sense that is prescribes when projects should be considered for termination, and it therefore has predictive potential. It is also empirically valid, in the sense that it explains cases of actual IT project terminations, as we shall demonstrate below with the case summaries of three major terminated government IT projects in Denmark.

#### 5.3 Theory of IT project termination and the marginal cost trap mechanism

The marginal cost trap helps explain why it is not always rational to terminate projects, even when project cost exceeds budgets. This in turn helps explain why a rational criterion for project termination is not trivially linked to the triple constraint based on total cost, and why therefore a separate criterion for project termination, is warranted.

Consider an imaginary 12-month IT project with planned benefits worth £18m and planned cost of £12m. When the project starts (month zero) it is planned to generate a net value of benefits (Net Value) of £6m.

- **Figure 1: Marginal Cost Trap**
After three months, the project has spent €3m, and the project manager or the contractor estimates that the project cost (EAC$2). Estimate at Completion) will increase from €12m to €24m (EAC estimate at Completion is the estimated or re-estimated total cost of completing the project). ETC (Estimate to Complete) is the estimated or re-estimated cost to complete the project. EAC and ETC project management terms and concepts used in the "earned value" concept, and in project accounting under Percentage of Completion Accounting regimes. €15m, so that now (at month three) the cost to complete the project will be €12m (the total cost of 15m less the 3m spent in the first three months).

The cost spent in the first three months is non-recoverable, i.e., sunk cost, so rational economic analysis says that the project should continue, because the value of the benefits still justifies the cost to complete the project (ETC: Estimate to Complete), in fact, with the same net marginal value of benefits (Marginal Net Value) as the original plan (€18m - €12m). Imagine further a similar situation after six and nine months in the project, see figure 1.

The project has now fallen into the marginal cost trap, which has led to the continuation of a project that has turned out to be unattractive. If, however, at any time during the project the cost to complete the project should be estimated to exceed the value of the benefits of the project, then the project should be terminated. In this case the project owner must steer clear of another trap: the sunk cost fallacy, or escalation of commitment (Arkes & Blumer, 1985; Duxbury, 2012; Flyvbjerg, 2021; Garland & Newport, 1991; Gnia, Swanson & Gainsky, 2009; Heath, 1995; Kahneman & Tversky, 1979, 2000; Keasey & Moon, 2000; Sharp & Salter, 1997; Tan & Yates, 1995; Westfall, Jasper, & Christman, 2012; Zeeelenberg & Van Dijk, 1997). The sunk cost fallacy is what makes project owners reluctant to terminate projects they have already invested in, even in cases where doing so would be economically sound. For the individual project decision maker, on the other hand, it may be a different matter: Economic analysis of the future benefits of projects may be complex, and information not readily available or transparent, so rational analysis may be bounded (Kahneman, 2003; Moon, 2000; Sharp & Salter, 1997). This may lead to overoptimistic and irrational expectations for the future performance of ailing projects, so that they are allowed to continue rather than be terminated. Hence the “stickiness” of IT projects.

An implication of this condition of project ownership is that in some ongoing projects with incremental cost escalation, there may be no point in time where it is rational to terminate the project, even though it can be foreseen that the project will never be worth the original investment. The project in figure 1 will likely be considered unsuccessful, but based on purely rational economic analysis, it should not be terminated. In the practical project world, the project owner will probably, and for good reason, at some point lose confidence in the project, or the contractor’s ability to deliver it, and then terminate or reconfigure the project.

In many cases, some value - for example valuable learnings, or re-deployable modules - can be recovered from failed projects, see for example Yeow and Chua (2020). But psychological rationalizations after the fact, e.g., hindsight bias and other biases (Flyvbjerg, 2021) may be deceptive, and may overshadow the assessment that in hindsight, we would have been better off by not undertaking the project in the first place.

IT project work is difficult, and actions that we in hindsight would have wanted differently are inevitable. In fact, exaggerated risk aversion can probably hinder progress, or be too costly. The fruitful potential of hindsight and ex post analysis is not criticising the past but improving the future.

Ways to mitigate the risk of falling into the marginal cost trap include a) better project preparation and planning - including better feasibility studies and contingency provisions, b) incremental approaches, for example agile, where project outputs are implemented continuously and the value of benefits assessed incrementally, and c) removing experiments from the project execution phase, for example by using prototyping, proof of concepts, and small scale technology assessment at the front-end, and before commitment-to-build in order to remove knowable unknowns from the project execution phase.

6. Cases of IT projects evaluated as failures
In this section we will apply the proposed concept and definitions of IT project failure to five Danish government IT projects with more than €30m in project spending that have been evaluated as failures by project sponsors and major stakeholders from 2010 to 2015. These example cases will be used as plausibility probes (George & Bennett, 2005; Levy, 2008) for the presented set of IT project performance criteria associated with ex-post attributions of project failure, and for the theoretical predictability of IT project termination. The five projects considered by stakeholders as failures of varying degree include two completed, and three terminated IT projects.

6.1 IT projects evaluated as failures
The two projects analysed in table 3 are examples of Danish government IT projects, which stakeholders have evaluated as failures. The evaluations of these projects as failures, however, are not uncontroversial. Furthermore, both projects have produced systems, which are now in operation, providing functionality, and delivering benefits.

<table>
<thead>
<tr>
<th>Case</th>
<th>Justification for IT project termination</th>
</tr>
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<tbody>
<tr>
<td>POLSAG</td>
<td>A committee appointed by the government to review the project found that the project represented an &quot;unsatisfactory business case: it would be time consuming, costly and risky to solve the problem with the system. It would be 'throwing good money after bad' [...]. Given the cost, the net value of the benefits would be very limited.&quot; (Rigsrevisionen, 2013).</td>
</tr>
<tr>
<td>PROASK</td>
<td>A threshold was not achieved in the latter phases of the joint system development - prior to taking the system into production, concerns were raised that the planning assumption of staff reductions enabled by the new IT system would not hold. External consultants were commissioned to review the situation and they concluded that rather than enabling staff reductions, the new IT system would require additional staff. The consultants restructured the business case for the project and concluded that the net present value over eight years of taking the new system into operation would be €57mn higher than continuing operation of the existing IT system, and that operational cost of using the new IT system would be from 34% to 58% higher that operational cost of using the existing system.</td>
</tr>
<tr>
<td>EFI</td>
<td>A government commissioned external review concluded that it would not be economically viable and not technically feasible to correct the system i.e., it could not, within reasonable constraints, be brought to a well-functioning state, where it would generate value (Accenture, 2015a; 2015b, 2015c; 2015d; 2015e; Kammerdovanked).</td>
</tr>
</tbody>
</table>

Table 3: Cases of IT projects evaluated as failures (Rigsrevisionen, 2010, 2011)
The definition of IT project failure presented includes 7.1 Practical implications termination, and we have shown that the termination are, or should be, terminated. The theory of IT project explain why not all projects with shortfall of objectives the critical nature of commitment-to-build decisions. We the so-called “stickiness” of on-going IT projects and highlights the words, once commitment-to-build has been made, the project, or a more cost-effective alternative is be terminated if:

owner perspective. An IT project can be expected to on an investment view of projects, and a sponsor and on the basis of: Financial or non-financial benefits, functionality, constraints (budget, schedule, scope of delivery), effects of undesirable escalation of commitment in ongoing projects, and because the theory sets rational boundaries for budget extensions, when baselines are reset, which is frequent in IT projects. In this way, the presented concept of IT project termination can support unbiased decisions to terminate unviable IT projects to reduce losses caused by shortfalls in project performance, or conversely, support the continuation of projects where the cost to complete the project is justified by expected benefits.

The marginal cost trap mechanism explains the importance of the original project budget in a domain where it is not sunk cost for that project cost is also at multiples of the original budget. Furthermore, the marginal cost trap highlights the importance of commitment-to-build as a critical moment, where the basis for economic project evaluation changes from total cost to marginal cost.

Ways to mitigate the risk of falling into the marginal cost trap include a) better project preparation and planning - including better feasibility studies and adequate risk cont-in-gency provisions, b) incremental approaches, for example agile, where project outputs are implemented continuously and the value of benefits assessed incrementally, and c) removing experiments from the project execution phase, for example using prototyping, proof of con-cepts, and technology assessments at the front-end, and before commitment-to-build in order to remove unknowns from the project execution phase.

8. Acknowledgements
We are grateful to Peter Morris, Peter Sestoft, Bent Flyvbjerg, Cecil Chua, and the anonymous reviewers of The Journal of Modern Project Management for their comments and suggested improvements to previous versions of this paper.

9. Full Disclosure
The author was from 2010 to 2013 employed in a senior executive role by the main contractor for two of the five IT projects in section 6, and directly involved in the projects. The research presented in this paper is co-funded by the Danish Ministry of Finance. The author is a member of two Danish government oversight committees that review major IT projects, but none of the projects mentioned in the article. These facts are stated as a formality, they do not constitute conflicts of interest.

10. Research Limitations and Future Research Directions
There are other possible explanations of the “stickiness” of IT projects than the marginal cost trap presented in this paper, including explanations based on strong theory from behavioural science, for example the sunk cost fallacy, or escalation of commitment (Ariely & Blumer, 1985; Duxbury, 2012; Garland & Newport, 1991; Gunia et al., 2009; Heath, 1995; Kahneman & Tversky, 1979, 2000; Keasey & Moon, 2000; Sharp & Salter, 1997; Tan & Yates, 1995; Westfall et al., 2012; Zeelenberg & Van Dijk, 1997). For a comprehensive overview, see for example Flyvbjerg (2021): We consider the marginal cost trap presented in this paper as a complementary explanation rather than a rival alternative, since explanations rooted in behavioural sciences may well have rational elements.

The focus of this paper is run-of-the-mill commercial IT projects, and the relevance, validity and applicability of the findings beyond this scope have not been investigated. Some respectable academics are opposed to defining IT project failure in terms of economic performance, and they argue that for example the learning of the project organisation, or the applicability of work done in other contexts must also be considered. From that point of view, the analysis in this paper may seem incomplete. However, for the type of IT project in focus, economic performance - in a wide sense - it the major criterion for failure. The theory of the marginal cost trap is based on a small number of cases of Danish government IT projects, and even though the rationale is based on generally accepted investment concepts, the study would benefit from cases of IT projects in other sectors and regions.

10.2 Future Research Directions
The definition of IT project failure and failure criteria presented is a compact synthesis of the definitions and criteria found in the literature, which will allow our ongoing research in IT project failure to be explicit, specific, and well-defined with respect to the object of study. The reference definition of IT project failure presented is a respectful update of Morris and Hough's milestone definition from 1987 based on Morris’ own later work, and on the reviewed literature that we have found relevant for the project type in focus in this paper: run-of-the-mill commercial IT projects.

The separation of the assessment of IT project performance in neutral terms from the value domain of ex-post attributions of “failure” will be helpful for case studies and project postmortems, because it will support the factual assessments of performance without de- motivating project participants by using the stigmatising, derogative and contentious term “failure”.

We hope that the rational theory of IT project termination and the marginal cost trap mechanism presented here will be used, discussed, and critiqued by academics and practitioners with an interest in the type of IT project in focus here.

In future research we will apply the results of the work in this paper: The definition of IT project failure and the marginal cost trap to other types of IT projects than the ones used in this paper: Danish Government IT projects.

References


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## Appendix: Notions of Project Failure

<table>
<thead>
<tr>
<th>Year</th>
<th>Authors</th>
<th>Concept of Failure</th>
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<tbody>
<tr>
<td>1975</td>
<td>Lucas</td>
<td>System failure: System not used or not appreciated by the organisation.</td>
</tr>
<tr>
<td>1984</td>
<td>Fortune and Bignell</td>
<td>System failure is shortfall between performance and standards. Classifications of failure types: Type 1: Objectives not met; type 2: Undesirable side effects; type 3: Design failures (e.g. a fuse); type 4: Inappropriate objectives.</td>
</tr>
<tr>
<td>1986</td>
<td>Gilbreath</td>
<td>Project failure: Failure to meet (reasonable) stakeholder expectations. Failure is &quot;the sum&quot; of planning failure and execution failure.</td>
</tr>
<tr>
<td>1987</td>
<td>Lytinen and Hirshheim</td>
<td>Project failure: Expectation failure (failure to meet expectations of stakeholders). The analysis also discusses: Correspondence failure (failure to meet specified requirements); process failure (failure to meet budget and resource constraints); target failure (the system fails to be adopted by users).</td>
</tr>
<tr>
<td>1988</td>
<td>de Witt</td>
<td>The success of a project and project management may be determined by evaluating performance against success criteria or objectives.</td>
</tr>
<tr>
<td>1993</td>
<td>Sauer</td>
<td>System failure: Failure to survive; as long as the system can attract funding the firm must fulfill organisational need, and therefore not be a failure.</td>
</tr>
<tr>
<td>1995</td>
<td>Cole</td>
<td>Runaway project, failed significantly to achieve its objectives and/or exceeded its original budget by at least 30%.</td>
</tr>
<tr>
<td>1995</td>
<td>Standish Group</td>
<td>Project success: Completed on time, within budget to original specification. Project challenged: Completed and operational but delayed, over budget and reduced scope. Project impacted: Canceled during development cycle.</td>
</tr>
<tr>
<td>1996</td>
<td>Flowers</td>
<td>Information system failure: The system is abandoned before completion, or the system does not perform as intended, or the system is rejected and underutilized by users, or cost of developments exceeds benefits provided by the system.</td>
</tr>
<tr>
<td>1998</td>
<td>Glass</td>
<td>Runaway project: Follows Cole 1999, but the cost or schedule failure threshold is 100% rather than Cole’s 30%.</td>
</tr>
<tr>
<td>1999</td>
<td>Linberg</td>
<td>Project failure: The project is a failure, if it is not a learning experience for software developers. Other failure concepts, e.g. the triple constraint, are less important.</td>
</tr>
<tr>
<td>2000</td>
<td>Brown</td>
<td>Project failure classification criteria: non-delivery, late delivery, delivery over budget, failure to match the required specification or requiring significant changes. (According to Brown 2001, these are the criteria of the UK National Auditor’s Office).</td>
</tr>
<tr>
<td>2002</td>
<td>Yardley</td>
<td>Types of IT project failure: Degradation of business capability or competitive advantage; increase in operating costs; failure to meet critical business requirements; low user satisfaction; loss of control (of requirements or planning).</td>
</tr>
<tr>
<td>2003</td>
<td>Ewuusi-Mansah</td>
<td>Two categories of software failure: 1) failure to meet user expectations; 2) failure to produce a functioning system (development failure). Software development failure: One of the following: 1) failure to “achieve the functional objectives of the project”; 2) failure to meet “the original cost or schedule estimates.”</td>
</tr>
<tr>
<td>2002</td>
<td>Wilson and Howcroft</td>
<td>Project failure is constituted by non-achievements of standards agreed, for example requirements, budget, schedule, termination, cost not justified by benefits. Wilson and Howcroft distinguish between project failure, system failure (not working properly) and user failure (the system is not used).</td>
</tr>
<tr>
<td>2003</td>
<td>Yourdon</td>
<td>Death march project: exceeds schedule, budget, staff resources by more than 50 per cent.</td>
</tr>
<tr>
<td>2005</td>
<td>Nelson</td>
<td>Distinguishes “Process-based measures of project success” (triple constraint) from “Outcome-based measures of success” (use, learning, and value). Combinations include “Failed successes” (process success and outcome failure) and “Successful failures” (process failure and outcome success).</td>
</tr>
<tr>
<td>2005</td>
<td>APM</td>
<td>Project failure is contingent on stakeholder expectations, since “Project success is the satisfaction of stakeholder needs and is measured by the success criteria as identified and agreed at the start of the project” (APM, 2005). A later version of APM’s Body of Knowledge excludes an explicit definition of project success.</td>
</tr>
<tr>
<td>2006</td>
<td>IPMA</td>
<td>Project failure is contingent on stakeholder expectations, since project success is defined as “the appreciation by the various interested parties of the project outcomes”. This definition is more challenging than “to produce the project deliverables within time and budget, which is only part of it.” (IPMA, 2006).</td>
</tr>
</tbody>
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