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Causal Relationship Between Project Financing and Overruns in Major Dam Projects in Africa

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Abstract

Purpose: Cost and schedule overruns are rife in dam projects. Normative evidence espouses overruns as though they are inimical to development and prosperity aspirations of stakeholders. This study examines causal relationship between project financing and overruns.

Research Method: Causative data were extracted from completion reports of 28 major dam projects in Africa. Each of the projects was financed jointly by up to 10 international development lenders. Relationships between causes of overruns and project outcomes were analysed.

Findings: Analyses elicit indicators of remarkable correlations between finance procedures and project outcomes. Lenders' disposition to risk attenuation was the main debacles to project success. Interests had mounted whilst release of fund was erratic and ill-timed. Finance objectives and mechanisms were grossly inadequate for projects' intense bifurcations. Projects had slowed or stalled because lenders' risks attenuation processes were purposed to favour lenders' objectives, and not projects' interests. In addition, Findings also show *project owners' own funds* and *number of lenders to a single project* correlates with overruns.

Implications: Findings imply commercial complexities around major projects. They also show transactions are shaped by subtle (mis)trust behaviours in project finance procedures. Thus, scholarly solutions to project performance issues should consider behavioural issues of stake-holding parties more broadly, beyond contractors and project

owners. Project finance ecosystems are vulnerable to major actors' self-interests, opportunism, and predatory conducts. Borrowers would manage this by developing and improving their capacity to build resilience and trust. Evidence shows intense borrower-nations in Africa have limited capacity and acuity for these.

Originality: This study contextualises megaprojects in complexity rather than cost. Its additionality is in how finance steers absolute control of project environment away from project owners, and how finance administration triggers risks and overrun.

Keywords: Africa, causality, dam, developing countries, project finance, project outcome, risk management, water infrastructure, zero vision.

Introduction

Normative studies have sought to explore how and why major projects experience overruns in costs and schedules. The central argument in this is in two folds. Ansar *et al.* (2014) and Flyvberg *et al.* (2003) question whether overruns are (or should be) inevitable. Aibinu and Pasco (2008) think overruns should be seen as 'necessary evil' – *that is,* a tolerable 'disorder' that is necessary to deepen stakeholder satisfaction where expectations are *soft*. Ahiaga-Dagbui et al. (2015) and Ansar *et al.* (2014) argue research outcomes abound in both perspectives about overruns. However, project outcomes have remained largely unchanged. Projects still run over budgets and schedules, and they often end-up with less true value than the capital invested in them (Flyvbjerg *et al.*, 2018).

Love *et al.* (2014) underline a substantial knowledge gap in overrun research. They argue most studies on overruns only identify causatives (*that is, what* causes overruns), whereas the question of causality and causations (*that is*, *why* and *how* overruns occur and metamorphise) are often not addressed defintively. Love and their team explain this as why effective practical solutions are impossible to come by unless researchers pay attention to understanding causations more than identifying causatives superficially. For example, Cantarelli *et al.* (2012:92) explored overruns in transportation infrastructure projects. They found overruns decreased with project size in rail and road projects, however they found no clear relationship between project size and overruns in infrastructure projects generally. Also, Flyvbjerg (2008) and Flyvbjerg *et al.* (2018) ascribe overruns to behavioural issues amongst primary stakeholders in a project environment. They think overruns occur because project owners and their estimators are delusional, or because contractors mislead deliberately. However, the findings of Olatunji, Orundami and Ogundare (2018) regarding cost variability and bifurcations do not support Flyvbjerg's theory of optimism bias and strategic misrepresentation. Olaniran *et al.* (2017) also provide considerable evidence suggesting theoretical understanding of the relationship between overruns, project stages and project sizes may have been inacurate in the studies of Flyvbjerg and their team.

Regardless of interpretational nuances, challenges of major projects still persist. Water infrastructure such as dams of national importance are an example of this. Dams' economic importance include their relevance to commerce, food production, energy, tourism as well as life and ecosystems. Where dams are conceived as major projects in developing economies and their objectives are not realised fully, ripple effects arising from their potential failure had often weakened the economies and social sanity of host communities. In addition, procurement failures in dams have

considerable potential to trigger significant crises nationally and regionally (Nyarirangwe and Babatunde, 2019; Tshidavhu and Khatleli, 2020). Galli et al. (2022) give a robust example of these in their study on the depletion of Lake Chad, the world's second largest fresh water body at some point in its history. Lake Chad depleted from its original coverage area of 26,000km^2 in 1950s to 2,000km^2 in 2017. Galli and their team found strong correlation between the depletion of the Lake Chad and the proliferation of armed conflicts in the Lake Chad region. It is their conclusion that the situation of Lake Chad is the single most notable trigger underlying the formation and surge of insurgencies in Sahara Africa.

Gregory's (2020) study on six major electric power generation projects in South Africa found governance, scale and scope often influence development performance of major projects in sub-Saharan Africa. In addition, a review by Damayanti *et al.* (2021) shows performance of major projects can be linked to complexity, a phenomenon that is often difficult to measure. Damayanti and their team rationalise complexity to structural and social factors' interrelatedness, non-linearity and emergence as though these are contextual to project attributes and performance. Borrowing to finance projects is a part of this: the relationship between financing and project outcome is such that contributes to benefits' consolidation or destabilisation of stakeholders' development potentials (Aalders *et al.,* 2021). Siemiatycki (2018) explains how poor performance undermine potential socio-economic, political and environmental benefits that could be derived from major projects. Thus, overruns and their economic impacts pose critical intellectual challenge to projects' research. One major element of this is the complex interconnectedness between project financing and socio-economic and political considerations underlying project success.

Chaos theorists are clear about non-linear relationship between project's internal systems, external events and project outcomes (Galacgac and Singh 2016; Singh and Singh 2002). An implication of this is that overruns can be caused by external unrelated events to which neither project owners nor contractors have absolute control over. The objective of this study is to investigate the role of project finance in the outcomes of major dam projects in Africa. Soft relationships between financing and project success are explored with a view to analysing overrun causalities and outcomes of major dam projects as an outcome of borrowers' [project owners] vulnerabilities to creditors' opportunistic and exploitative conducts. The study is structured in three parts. First, a review that challenges extant understanding of dams as major and mega projects (MMPs) and how the direction of thoughts elicited in this study applies to developing economies and project financing. This is followed by the presentation of the research method and data analysis, and thereafter, the practical and theoretical implications of the findings.

The Reality of Major and Mega Projects (MMPs)

Major projects are critical national economic assets, shaped by complex and uncertain phenomena. Normative literature had often struggled to articulate accurate definitions for major and mega projects. For example, Flyvbjerg (2011:322) defines major projects as projects where cost exceed US$100 million, and perhaps a part of a major programme where cost could exceed US$1 billion. Likewise, many authors agree a megaproject has a development budget exceeding US$1 billion (Flyvbjerg 2014, Jergeas and Ruwanpura 2010, and Olaniran *et al.* 2017). These definitions suggest development budgets can define projects' actual costs and sizes definitively. Such simplistic views are not essentially adequate. Morris and Hough (1987) think such definitions portray MMPs as though they are poorly understood; the

wrongful conceptualization of research around such definitions explain why related research outcomes have had feeble impacts, and why MMPs are often not managed adequately.

Mišić and Radujković (2015) and Gutierrez *et al.* (2019) provide alternative viewpoints that underlie realistic bases for deeper understanding as to why project size is not defined by budgets or costings only. They think project stakeholders seldom have the same views regarding a project development budget. Owners' budget [a *price*] is not the same as contractors' budget [*cost*]. The former contains contractors' *margin* which may not have a conclusive relationship with actual development costs or project size (Love *et al.,* 2017:1090). This is also well argued in Flyvbjerg's (2008) theory of optimism bias and strategic misrepresentation, Green's (1989) theory of contractors' rationality and Ray *et al.,* (1999) theory of amorality in contractors' business behaviours. Flyvbjerg posits development budgets do not often represent project's true costs because of uncertainties and stakeholders' behavioural issues. Green's view is that project stakeholders enjoy the liberty to make decisions and portray their estimates in ways that provide them greatest utility in their project outcomes. Ray's position aligns with this also. They think profit-making is an amoral consideration that has limited linear relationship with determinate factors. A clear implication of these is that a US$100 million to US$1 billion budget could deliver projects of varying sizes and complexities. A definition that is based on a dollar amount can only be true for a subset of projects, not for all circumstances.

Cost seldom define project complexity. Vidal *et al.* (2011:719) defines project complexity as the property of a project which makes it difficult to understand, foresee and keep its overall behaviour under control. Attributes of complexity would remain noticeable regardless of whether information about project's systems is considerably complete. Complexity explains interdependencies between project sub-systems and

project outcomes. Less complex projects consist of subsystems that can interact predictably to determine project outcomes. Such predictability is less certain as complexity increases. MMPs are sufficiently complex and often characterised by the numerosity of stake-holding entities (Damayanti *et al.*, 2020). They comprise complex components, each of which can unpredictably shape the outcomes of other components and the overall projects. In addition to the complex interdependencies within the components of MMPs, Olaniran *et al.,* (2017) explain how unrelated events often trigger major outcomes in them. Further explanations on the applications of systems dynamics and *chaos*, to the management of MMPs, have been reported by Bardyn and Fitzgerald (2005), Singh and Singh (2002), and Tse and Robb (1994). These studies conclude that complex projects are in a continuous state of disorder and could become chaotic (an irreversible state of disorder) when impacted by marginal change events, including events triggered by externalities.

Complexity manifests differently in different project types. Vidal *et al.* (2011) summarize measures of complexity to include computational complexity of interdependencies between activity sequence, project structure and system thinking. Additionally, complexity also varies by project environments. For example, Meyrick (2011) provides comparative evidence across Australia, France and the United Kingdom. They suggest the cost of a small transportation infrastructure project could be equivalent to the cost of a mega housing project. Newman (2014) corroborated this. They elicited the range of $/km of some road projects in Australia as $350-$414 million, whereas the costs of housing and rail projects are much lower than these. Thus, triggers of variabilities are a result of complexity, in relation to cost, vary in these different project environments.

With this understanding about complexity, it is important to consider the many dimensions of complexity in dam projects. Dams require intense technical and

resourcing complexities. Olatunji (2018) gives an example of this whilst analysing the first attempt of Africa's most populous country, Nigeria, at developing an integrated steel plant, the Ajaokuta steel plant. The study shows Nigeria struggled with manpower to design and operate the plant. In addition, Nigerian authorities had not realised they needed to prepare for the heavy resource consumption of the plant about a decade ahead. Another dimension to the complexities underlying dam projects is in how different parties respond to project risks: owners' vulnerabilities to finance situations would determine how owners shape their objectives, and how other players play their roles. Amongst other dimensions, several studies have added uncertainty, culture and innovation as elements of complexity (Cantarelli 2020; Dao et al. 2017; Lessard, Sakhrani and Miller 2014; Luo et al. 2017).

Challenges of Major and Mega Projects in Developing Economies

Development of MMPs often come with intense political and commercial tranactional implications, both locally and internationally (Pitsis *et al.*, 2018). This often adds to the dynamism within MMPs, including the long-term potential to transform socio-economic and political landscapes of MMP owners. Layers of complexity in this are often visible in the manner in which MMPs perform in the course of their development. Whilst such complexity are often reported in project management literature, vague or simplistic solutions are aften ascribed to them. For example, Flyvbjerg *et al.* (2018) associate overruns with planners and contractors' biases. However, they chose to limit the strategic siginificance of the nexus between politics and finance in project governance to uncertainties in stakeholders' behavioural issues. These causalities may justify overruns. Nonetheless, the scientific bases to put them to underestimation or stakeholders' deliberate bias are not evident as causations were not established conclusively in Flyvbjerg's study.

MMPs in Africa are susceptible to political instability, civil unrests, logistic issues and circumstantial technical difficulties. These may appear as establised layers of difficulties that add to estimating error and contractors' misrepresentation described by Ansar et al. (2014). Notwithstanding, MMPs require intense technical and financial commitments that are regularly beyond in-house capacity of project owners. As often the case in countries where economies are of a limited capacity, borrowing to finance MMPs is rife. Political expediency and lack of capacity – to define own needs and to evaluate the true cost of indebtedness - had meant MMP owners in Africa who borrow to develop their projects are exposed to critical vulnerabilities. Such borrowers are in a position of opportunistic exploitation, including strict enforcements of lenders' risk attenuation protocols such as imposition of strange structural adjustment policies.

Delmon (2021) and Sorell (2008) explain some moral obligations required of lenders in every finance project as though their fundamental components should include commercial dignity and human right, particularly while lending for development projects. These authors argue creditors are at risk if they lend to MMP owners who desire a loan for benevolence, rather than mutual commercial benefits. In addition, such creditors are at more risks if they fail to market their product or their intention to maximize profit transparently, and had portrayed an operational model that weaponises information gaps and subtle thrust whilst attracting borrowers to trust them (Güven, 2017). Such risks include ethical burden, potential dysfunctional relationships, and loans eventuating into irrecoverable investments.

Asongu and Nwachukwu (2018) argue that the sparse availability of finance, in particular to developing countries, may force borrowers to accept credit terms that may lead to the full potential of the debt incurred not being realized. An overwhelming evidence in their study confirms the observation: borrowers often lack

capacity to manage themselves and their proposed MMPs when they are at a despirate position of need. They are not able to control or predict the underlying factors causing overruns in their projects either. In contrast, international creditors do have a wealth of knowledge and capacity to draw strength from (Toffler 2022). Large commercial lenders can be definitive about their risk perceptions and do have access to extensive resources to demystify complex uncertainties. Borrowers who are consumed by desperate needs seldom have these capacities. Thus, one dimension to negative causal relationship between project finance stakeholders is in understansing the mismatch between infrastructure lending and the objectives and expectations of owners who borrower for project development.

For greater clarity, credits are awarded on the basis of development estimates as though they are firm and definitive, even when project descriptors are uncertain and inconclusive. This means such finance decisions are taken at a time when actual work methods, contract circumstances and business character of development contractors remain largely unknown. If otherwise, approved amount post-application, timing of fund release, lending conditions are still uncertain, and will not be included in project considerations before costing decisions are finalised. Thus, it is incumbent to expect remarkable headwinds when reality challenges unsubstantiable cost bases of projects. In addition, projects' payment mechanims are rendered ineffective and will trigger overruns when credit approval processes and fund release from such facilities are delayed substantially or are made vulnerable to complications (Olatunji, Aje and Olalusi 2017). Implications of these to variability of project cost are not often factored into credit considerations nor pre-projects' cost estimates. In these circumstances, it is arguable that project variabilities are poorly understood by stakeholders – borrowers are optimistic they will not occur (hence firm estimates), whilst creditors' objective to maximise benefits to themselves are favoured as they cautiously deploy risk

attenuation protocols that meant they are less vulnerable than borrowers (hence commitment to pre-project's firm estimates). If variabilities are inevitable, and are ignored during definitive costing, overruns will occur. Their management would become chaotic – unpredictable, unkind, uncontrollable and problematic; the underlying cause being the inability of project financing to account for project's true costs.

Trust behaviour in Financing Major and Mega Project

The relationship between a *trustor* (borrower) and a *trustee* (creditor) in a commercial lending situation is not entirely simple. Neither party can be completely certain that the information received from the other is absolute, accurate, unbiased and transparent (Asongu and Nwachukwu 2018). Although this may lead to mistrust and negative connotations to the reputation of the other party, it is crucial for both parties to attenuate their risk exposure arising from this. According to Li *et al.* (2019), Pitsis *et al.* (2018) and Turner and Xue (2018), the context of MMPs is such that lending relationship is often intended for transparency. Other objectives of such relationship include clarity of political and relational objectives, thorough understanding of asset values and the benefits that the projects are meant to add to stakeholders. Certainty seldom exist around these, especially in economies where public institutions are weak and project finance is constrained by inconsistent legal constructs. An imposing dimension to this is where MMPs are designed for social good rather than profitable commercial assets. In such an instance, if trust behaviour in lending is relational, project finance would become entangled in relational and moral complexities that becloud transparency. This had often resulted in lending and borrowing practices that are vulnerable to assessment biases, unbalanced loan conditions, unclear stakeholder interests, over-optimistic repayments conditions, unrealistic intention to

make profit, heavy enforcement conditions, influence on borrowers' policy-setting, loaded lending risks, and political clout (Güven 2017).

Annen and Knack (2018) insist that in the context of aid and lending, it is important to differentiate between bilateral and multilateral organisations. They argue multilateral lenders or aid providers have a stronger preference for a combination of requirements such as policy environment, poverty prevalence, performance of existing projects and a sensitivity to the country's level of debt distress. In addition to these, bilateral lenders or aid providers often consider political and commercial interests. Whilst the World Bank is the largest multilateral aid provider, it faces competition from emerging development banks and large non-traditional bilateral lenders like the China Development Bank. Lending by the World Bank through International Development Association (IDA) focusses on concessional lending to poor countries, whilst the World Bank's International Bank for Reconstruction and Development (IBRD) focusses on sustainable borrowers. The formation of various multilateral and bilateral development banks in the last decades is indicative of the emergence of the lender-borrower relationship as a new political economy (Luna, 2016). Güven (2017:499) asserts prominent international creditors rely on less-advantaged borrowers to retain their competitive edge and presence: they require "a strong presence in systemically important countries [in order to sustain] privileged status as an international organisation, justifying continued donor and political support for its operations".

An unscholarly think-tank report by the Institute of Developing Economics of Japan External Trade Organisation (IDE-JETRO) describes China's strategic expansion in Africa as a race to acquire or have access to resources, whilst offering finance with lower control over the effective use thereof, but a higher control over loan conditions (Thrall 2015). The underlying principle for credits provided under such approach is as

though a vehicle for foreign investment used to stimulate international trade and the creditor's economy, rather to alleviate or improve the lack of expertise or material availability in the borrowing country. A study by Dreher *et al.* (2019) shows how some international creditor agencies target political competitiveness. They also focus on imbalanced economic, political and commercial returns for the creditor, including other activities that border on irresponsible or unethical lending. Graeber (2014) has accused various American banks of using similar strategies during the 1970s: lending to dictators with loan conditions that allows minimal control or monitoring of the effective use of the finance, leaving these countries with excessive debt burdens when the dictators were overthrown. Besides the serious financial implications on the borrowing country's population, unbalanced loan conditions lead to less than optimal returns on the loan for the borrower (Asongu and Nwachukwu 2018). This often weakens the legacies of a MMPs as the true asset value may be lower than the actual cost of construction (Flyvberg, Bruzelius and Rothengatter 2003; Flyvbjerg 2021). In such instances, the economic benefits in terms of resource supply, wages and taxes are not realised, whilst the borrower pays premium interests on the loan or cede resources at the lowest possible price as a high-risk borrower.

In addition, certain loan arrangements invoke the fear of Dutch Disease [also known as the *resource curse*]. According to Daarty-Baah *et al.* (2012:187), such arrangements trigger a shift from "productive sectors such as agriculture and manufacturing to non-tradable sectors like resources, export and construction industry". This often leads to an appreciation of the exchange rate and a loss of domestic competitiveness of goods produced locally. Dartey-Baah, Amponsah-Tawiah and Aratuo (2012) accuse the World Bank of being conservative in their evaluations of African countries that are resource-rich and have large labour pools. They however note that these fears do not seem to be based on bad intentions, rather

on biases. As Adam and Bevan (2006) argue, beyond Dutch Disease, aid outcomes may not be straightforward, in particular in the case of the MMPs' development. They caution, "public infrastructure investment that generates a productivity bias in favour of non-tradable production delivers the largest aggregate return to aid, but at the cost of a deterioration in the income distribution" (p. 261). Daarty-Baah *et al.* (2012) argue further, as in the case of the Ghanaian's agrarian economy, conservative evaluations by international lenders and scarcity of available finance had forced borrower-governments to consider less favourable loan conditions that leads to suboptimal returns from bilateral or private lenders. Moreover, such situation had led borrowers to lose the chance to build their capacity towards a seamless and transparent management of future dealings.

This synthesis explains the vulnerability of MMPs and borrower nations: lending risk is high; borrowers lack capacity for due diligence and their projects are susceptible to finance conditions rather than support their planned project objectives. The main question in the heart of this research is: how do these vulnerabilities impact project outcomes?

Summary of Theories, Constructs and Implications

This study contributes to the trigger theories by Flyvbjerg regarding strategic misrepresentation and optimism bias (Flyvbjerg et al 2003; Flyvbjerg 2008, 2011, 2014, 2021 and Flyvbjerg et al 2018). The remit of these theories is that overruns occur in projects because of behavioural issues; *in that*, project owners often choose to underestimate (delusionally), whilst contractors often choose to be deceptive (misrepresent). However, Love and Ahiaga-Dagbui (2018) have questioned the premise of Flyvbjerg's theories. Their questions have bothered on conceptualisation of project size and reference costing e.g., whether there is a definitive relationship

between project size and costs, and whether overruns should account for variabilities in project scope through different development phases of a project or pre-project budgets are meant to be sacrosanct.

Meanwhile, as espoused in the background explanations to the review of literature above, there is more to the dynamics of project overruns than the relationship between project owners and contractors. Creditors do have vested interest. They determine what funds would be available, when, how and under what conditions. Borrower-project-owners are vulnerable; they seldom have capacity to control the circumstances of their projects and are often a victim of predatory behaviours of lenders and the dynamism of complex risks in project finance mechanisms. Thus, an incipient construct of this study is that the impact of behavioural issues in project finance is as important as Flyvberg's perception regarding causations of overruns from owners' and contractors' actions. This position is tested in this study.

Creditor issues is explained in normative literature to include complexities in underlying conditions of co-financing (Florescy and Brezeanu 2010), cashflow issues arising from erratic release of funds and ambiguous processes (Yescombe 2002), borrower's limited experience in risk shifting (Farrell 2003) and, variabilities and escalations (Shefrin 2001). Further, normative literature is replete with evidence as to how **external events** often trigger overruns. Examples of these include social and political factors (Catalão, Cruz and Sarmento 2021), econometric causes (Kleivbo 2017), public policy issues (Catalão, Cruz and Sarmento 2022) and social vices and instability (Catalão, Cruz and Sarmento 2023; Gaetsewe, Monyane and Emuze 2015).

Certain causes are also dominant in **project attributes**. They include misleading information underlying design, estimates, contract constructs and planned work methods (Love, Edwards and Irani 2011). Doloi (2013) also explains how projects are

vulnerable to incessant variations to project scopes, teams, and requirements. Cashflow and resources issues are identified by (Aje, Olatunji and Olalusi 2017; Olatunji, Orundami and Ogundare 2018). **Borrower-owners** also cause limitations in project outcomes. Where there is significant incapacity to deal with complex uncertainties, chaotic outcomes may emerge (Olaniran et al. 2017). Olatunji (2018) also explains project vulnerabilities due to owner's limitations in terms of policy, staff motivation to succeed and self-coordination. Not least, **contractors** are also confronted with issues relating to resource procurement (Olaniran et al. 2017). In addition, there are reports where contractors have been criticized for construction errors, limitation to deliver, safety issues and episodic commitment to ethos of business ethics (Jia et al. 2017; Love and Smith 2016; Pinto 2013).

These causal factors have emerged from keen consideration of the implications of Flyvberg's presentation of behavioural theories of strategic misrepresentation and optimism bias. They have been constructed as variables that can be measured to determine their impact on project outcome, with a view to showing the roles of project finance in the outcomes of major economic projects in debt-burdened economies. Dam projects are chosen for the study because of their national and international importance to Africa as a region, and because of the complex international finance institutions involved. Project complexity is defined by the project environment, rather than cost tags.

Research Method

An objective of this study is to investigate causality between project attributes such as budgets and schedule, funding and project outcomes i.e., whether project funding patterns, in relation to award budgets and schedules, could trigger project outcomes as 'fail' or 'success'. Causality requires observations of variables through controlled

experiments. Independent variables are manipulated to test their effects on dependent variables by holding other variables other than independent variables constant or controlled, by measuring statistical attributes of variables to explain their influences and by balancing variabilities through randomization. The following procedures summarize the procedures used in this study to investigate causality:

- The Conrolled environment for the study is defined. Vulnerabilities of project owners are common. They all rely on substantial borrowing for their project development. Their vulnerabilities to issues in finance protocols and mechanisms are similar. They all have limited depth in legal constructs around their borrowings, and in dealing with project uncertainties, and had borrowed around a time when they have had social crises.
- For the sake of consistency, data for the study were sourced from a single lender's open reporting system. Project type was a specific, *Dams*, filtered through a definite geographical area, *Africa*. The economic importance of marine projects was considered. All irrigation and energy dams in Africa were included in the analysis.
- Project completion reports (PCRs) were searched and obtained from published archiveal documents only from World Bank's websites. The search yielded 34 projects, out of which 28 were included in the analysis. Six projects were excluded because they have had insufficient information on the variables being analysed, by reasons of project failure or were incomplete and have not been acquianted financially at the time of the analysis. Official identification numbers of the projects are P00-0070, 631, 664, 834, 836, 854, 1232, 1250, 1291, 1414, 1423, 1482, 1488, 1592, 1597, 1602, 2007, 2566, 2596, 2600, 2659, 2710, 2743, 2684, 2917, 2999, 3036, 3054, 3150, 3160, 3164, 3166, 3264 and 3282.

- Focus of the analysis was on performance of MMPs in the nature of critical hydroelectric dam infrastructure in select African countries; namely Benin Republic, Burundi, Eastern African region (comprising Rwanda, Burundi and eatern Democratic Republic of Congo), Ghana, Madagascar, Malawi (3 Nos), Liberia (2 Nos), Kenya (2 Nos), Rwanda, Sudan (3 Nos), Swaziland, Tanzania (4 Nos), Zaire (2 Nos), Uganda, Zambia (2 Nos) and Zimbabwe.
- Data homogeneity was achieved by focusing on project delivery systems, approach to financing and transaction currency of projects; rather than localised economic nuances.
- All the projects included for analysis were financed by up to 10 international development lenders, including World Bank's IDA and other international institutions.
- Project reports provide evidence regarding project history from 1960s to 2022, number of lenders, project development processes and factors that led to the success or seeming failure of the projects. In particular, the study investigates causation probabilities in the relationships between budgets, outturn costs, portion of borrowers' own fund in project costs, number of lenders, measured cost performance and, planned and actual project duration.
- Causative factors were identified from each project report, and were analyzed to establish causation and impact.
- Relationships between factors were mapped cognitively in the reports analysed before statistical processes were undertaken.
- Although some studies have used spuriousity in data to argue that correlation does not prove causality, Zhang et al. (2011) have shown otherwise. They used correlation to explain how climate change causes large-scale human crisis. This

current study resolved spuriousity by ensuring the relationships between variable have clear logical explanations through in cognitive map.

- Regression and probability distribution analyses were undertaken to explain the variabilities of independent variables.

Statistical attributes of observed variables

12 projects, representing 42.85% of sample size, have had a price tag below US$50 million (Table 1). It is convenient for normative literature in traditional project management to group projects below US$50 million as though they are outside MMPs. However, as argued in the review of literature presented in this study, megaprojects are best explained by the complexity of platforms through which they are delivered, and they should be analysed by the complexity of their subsystems – that is, the interdependencies between their subsystems and how they are impacted by unrelated events. Layers of complexity in the samples include project sizes, socio-economic and political impact of the projects, national importance, involvement of international institutions, project delivery systems involved and currency of transactions. For greater clarity, US$50 million spent on a housing infrastructure project locally in the United States under strong institutions and naturally occurring and readily available resources may not be as complex as $10 million greenfield energy project in Tanzania where US$1 is about TZS2,500 (January 2023), and majority of the resources needed for the project are imported. In addition, a US$10 million financed in 1966 does not the same real value in 2023. At an average inflation rate of 3.97%, $1 in 1966 has a current equivalent purchasing power of $9.20 in 2023 (January). This situation of time value of money is more severe in Africa than it is in the United States. For example, clear evidence exists in World Bank's PCR No 11500 dated 1992, reporting on P00-

00703054.1 (Shaba Power System Rehabilitation project, Credit 1224-ZR) and P00-00703054.2 (Second Power Project, Credit 1712-ZR). The two projects were financed in 1982 and 1987 respectively, both as under US$50 million when contracted. The report shows official rates of the dollar rose from Z40.5 in 1984 to Z135,000 in 1992.

Moreover, complexity manifests differently in different project types. For example, a report by the International Renewable Energy Agency (IRENA) (2012) suggests small hydropower projects are more expensive than large hydropower projects. Sizes of power projects are measured only based on capacity of installed units (that is, not by cost or size of site but by systemic output). For example, a small hydropower plant is $1,300 - $8,000 per kilowatt capacity of installed costs, whilst a large hydropower plant is $1,050 - $7,600 per kilowatt capacity of installed costs. The dam size to produce these varies from country to country. A small hydropower plant in the United States can produce up to 100 megawatts, whereas the same size of dam can only produce up to 50 megawatts in China and Canada, 20 megawatts in the European Union and 1.5 megawatts in Sweden. New technologies are increasingly able to improve system efficiencies and productivity. This means contemporary energy projects that appear small can produce a large amount of energy, whilst traditional energy projects that occupy larger sites produce much less energy and they incur a high social costs and maintenance burdens. Thus, whilst it is prudent for stakeholders to choose innovative technologies that enable them build smaller and achieve efficient outcomes in improved quality and sustainable solutions, there are parts of the world where access to old inefficient technologies is still a challenge. Moreover, as some of the projects included for analysis were financed several decades back, with repayment still active to date, it is only appropriate to de-emphasize project technology as the basis for analysis.

Current energy projects are cost more than they did in 1960s, and they deliver higher energy outcomes in less expansive dam size and are less complex to achieve. This is evident in the IRENA's (2012) report, which concludes innovative technologies can be expensive in the short run, but they are cost-efficient in the long run. This does not mean old dams are less complex to procure. In context, a small hydropower plant in the US that has a capacity to produce 125 megawatts could cost up to $1 billion. This is equivalent to 2.5 small hydropower plants in China or Canada, and about 83 small hydropower plants in Sweden. Thus, such a project is not seen as large in Canada, China and the United States, whereas it is extremely large in Sweden (and very extremely large in Africa). Project size and complexity can be analysed further. For example, an installation of few smart (relatively small-sized) but expensive equipment does not define complexity, rather by the complex interdependencies between the project's sub-systems. These are defined in the objectives of this study to include correlations between budgets, outturn costs, portion of borrowers' own fund in project costs, number of lenders, measured cost performance and, planned and actual project duration

A multiple linear regression analysis was performed to identify the causal effect of various issues on cost (Y_{co}) and schedule overruns (Y_{so}). Linear regression analysis has been valuable in modeling and forecasting construction variables because of their relative simplicity in concept and application (Bee-Hua, 1999). It uses several explanatory variables to predict the outcome of a response variable. All the dam projects considered in this study varied in their characteristics such as award budget ($million) ($x_1$), number of lenders ($x_2$), planned duration at contract award (months) (x_3), IDA fund ($million) ($x_4$), and amount of borrower's own fund ($million) ($x_5$). These variables were included into the model as control variables. Five variables, measured on a dichotomous scale, were included as independent variables. They are creditor

issues (Z_1), external issues (Z_2), project-related issues (Z_3), borrower issues (Z_4) and contractor issues (Z_5). These variables and their subsets were extracted consistently from World Bank's PCRs in relation to how they interract to explain project outcomes (overrun causations). Table 1 provides a summary of these variables, by number of projects they impacted and the impacts they triggered. Findings from these are expected to explain borrowers' vulnerabilities. For example, frequency and severity of impacts will show which of the variables caused the most overrun and how these affect project outcomes and owner's objectives. Hierarchical regression analysis procedure in SPSS software was used for the analysis. Conditional probability of cost overrun under each variable was calculated to further explore the link between outcomes of correlation analysis and indicators of causality between elements of project financing and project outcomes. Binomial distribution density function calculator in Minitab software was used in this analysis also.

Table 1: Causes of Overruns and their explanatory sub-variables and impact (as sourced from project reports)

Causative Factors	**Impacted projects**	**Impact**
Creditor issues [Z_1]	16	Inflation, environmental, political and economic changes created spontaneous effect on projects.
Complex co-financing procedures.	13	Heavy administrative and co-ordination burden imposed on borrower.
Release of fund was delayed.	9	Delay averaged 10.22 months. Critical funding issues. Slow payments to contractors. Contractors' advance payments were delayed. Consultants could not attend contract meetings. Late submission of drawings. Changes in government legislation.
Credit approval process was delayed.	4	Delay averaged 12.5 months. Project's economic ecosystem changed while approval delays lingered.
Erratic payment.	2	Unmeasured impact on cost and schedule.

Borrower had limited experience.	3	Distrust (hesitation) was evident. Borrower's agencies were not familiar with lending code. Procurement decisions were slow. Redesign, rescheduling, and rework were significant.
Escalation of cost of finance.	1	Escalation of project costs.
Extra-contractual extension to term of loan.	1	Additional items were added to the contract. This took three additional years.
External issues [Z_2]	18	Environmental, political, and economic difficulties.
Macroeconomic issues.	6	Escalations in exchange rate [triggered up to 49% cost overrun] and input resource prices [triggered up to 28% cost overrun]. Inflation [caused 59% escalation in the cost of a critical local element]. Increase in local and foreign components of project costs caused significant project modification.
Civil unrest.	5	Project delay [e.g., 24 months delay in the supply of critical electrical equipment in a project and 30 months delay due to security issues at the onset of another project]. Late payment to contractors. Work stoppage. Demobilisation. Price escalation. Budget overrun due to political instability averaged $18.3 million.
Disruptions due to access difficulties.	4	Difficulties in transporting materials and equipment. Unmeasured impact on cost and schedule.
Financial crisis in the region and globally.	2	Soft impact on development market. Demand management issues.
Morale issues amongst staff [due to political and economic situation around project].	2	Unmeasured impact on cost and schedule. Development approval was delayed in a project
Disruptions due to natural disasters.	2	Unmeasured environmental, political and economic impact on cost and schedule.
Capacity for competition in the local market is low.	1	Initial bids were uncompetitive.
Transnational political tension [between the borrower and their neighbour].	1	46 months schedule disruption. Legal costs [matter referred to international arbitration].
Government policy issues.	1	Soft financial impact on project cashflow.
Bankruptcy of the manufacturer of critical items of the project.	1	36 months disruption.

Technical resource available to project is inadequate.	1	15 months disruption.
Project-related issues [Z_3]	11	Variations, uncertainties, resourcing and contract issues.
Unforeseen underground situation.	6	Unexpected geological difficulties. Delay. Scope changes. Design changes. Rework. Modification of construction method. Delivery of critical components of projects was delayed. Cashflow issues.
Design errors.	4	Design and actual quantities are different significantly. Late start of procurement. Disputes arose due to price adjustments. Land expropriation issues. Cost increased due to redesign and rework. Schedule disruptions averaged 17 months.
Estimation errors.	4	Project commencement was delayed. Overrun: $40 million tigered in a project; unrealistic schedule added 7 months to another project. Late project take-off [contract award of a project was delayed for 24 months].
Change of project team.	3	Disputes involving borrower, consultants, and contractors
Coordination issues.	3	Cost accounting was weak. Progress report was not produced on time. $350 million was not released. Another element of the project was reduced by $70 million. Where completion was timely, coordination issues caused 2 months delay. Miscommunication caused 11 months delay in a project.
Uncertainties in project requirements.	3	Issues in related projects [valuation of assets and liabilities of a borrower's agency took longer than expected; $38.2 million in new cost, creditor did not release fund]. Implementation delay (cost rose by up to 25% in some projects].
Issues in technical reports.	2	Project studies were not completed to schedule – 30 months added to project.
Scope changes.	2	Procurement and construction difficulties. Soft impact on schedule. Borrower needed to find new financiers. Design changes.
Contract design issues.	1	Several changes in project scope. Insufficient emphasis on maintenance in contract design. Improvement in operating performance and rehabilitation of operating facilities were delayed. Technical assistance and training were unsystematic. Soft impact on time.

Resource shortage.	1	Shortage of reinforcing steel triggered 24% rise in development cost.
Cashflow issues.	1	Shortage of local funds caused 6 months delay.
Borrower issues [Z_4]	**11**	
Lack of capacity to implement.	3	Unmeasured impact on cost and schedule.
Psychological issues amongst staff.	3	High attrition rate amongst borrower's staff aggravated financial issues. Accommodation was not provided to the contractor on time. Discontent amongst staff. Leadership and administrative disruptions within a critical agency of the borrower.
Self-coordination issues.	3	Poor analysis of contractors bid led to substantial award to contractor. Deviation from Bank procurement guidelines in bid and contracts documents caused financial constraints and 24 months delay. Loan agreement approval delayed for 3 months. Own work not completed to schedule caused 24 months delay on a project.
Uncertainties.	1	Deficient specification of owner's requirements led to scope changes.
Policy issues.	1	Delayed tariff increase constrained a significant cashflow objective.
Optimism bias.	1	Viability analysis was a little too optimistic. Demand was lower than predicted; earning was inadequate. Borrower's policy did not favour financial viability of project. Delayed completion and commissioning triggered additional on-cost claims by contractors.
Contractor issues [Z_5]	**6**	Performance issues in relation to capacity to deliver and safety issues.
Procurement issues.	5	Soft impact on production costs and schedule. Delayed procurement, up to 20 months. Slow start of work caused 6 months delay in a project.
Lack of capacity to deliver project.	2	Soft impact on production costs and schedule. Contractor's bid was low; cashflow/funding constraints.
Safety issues.	1	Loss of life. Work was suspended to improve safety.
Construction errors.	1	Delayed mobilization due to fabrication errors in structural steel members.

Source: Authors' own work

Data analysis and findings

A summary of the data relating to the projects is presented in Table 2. Although 43% of the projects were awarded for development at less than $50 million, all the projects are of significant economic value to their owners. They all support regional economies for food, energy, environmental conservation and tourism. As a result, they have far-reaching implications to politics, industry, bilateral relations and finance. Owners relied on international creditors for 100% of the project funds in 86% of the projects. Where own funds had existed prior to development award in four projects, such amounts were 8-29% of budget. In addition, evidence in Table 2 suggests IDA is the most prominent development lender of the analysed projects. They account for more than 50% of the actual development costs in 46% of the projects. However, there are many other international lenders in the projects too. More than 60% of the projects had more than two lenders concurrently. Two projects, of a development budget of $127 million and $135.9 million respectively, had 10 lenders. IDA contributed 25 to 42% of the actual project costs in the two cases.

Insert Table 2

As shown in Table 3, 93% of the project did not complete to budget and schedule. Although only 57% were awarded above $50 million in development budget, about 65% of the projects finished above $50 million. 40.7% of the projects exceeded their schedules by more than 50% of their original schedule. Whereas 82.1% of the projects completed to budget or below their award estimates, only 7% of such projects were completed to their planned completion schedule. Variations in costs and schedules are summarised in Table 4.

Insert Table 3 & 4

Table 2: Descriptive statistics of study data (project cost)

Project Cost ($ million)	Frequency (%)		% Own fund (Budget)	Frequency (%)	% IDA fund (Actual)	Frequency (%)
	Budget	Actual				
<50	12(42.9%)	10(35.7%)	0	24(85.7%)	1–25	3(10.7%)
50–100	8(28.6%)	7(25%)	1–10	1(3.6%)	26–50	12(42.9%)
100–150	4(14.3%)	8(28.6%)	11–20	1(3.6%)	51–75	7(25%)
150–200	3(10.7%)	2(7.1%)	21–30	2(7.2%)	76–100	5(17.9%)
200–250	0(0%)	0(0%)			101–125	1(3.6%)
250–300	0(0%)	0(0%)				
300–350	0(0%)	1(3.6%)				
350–400	1(3.6%)	0(0%)				
Total	**28(100%)**	**28(100%)**		**28(100%)**		**28(100%)**

Source: Authors' own work

Table 3: Descriptive statistics of study data (project schedule)

Project duration (Months)	Frequency (%)		No. of lenders	Frequency (%)	Change in cost (%)	Frequency (%)
	Planned	Actual				
24–36	5(17.9%)	3(10.7%)	1–2	11(39.3%)	<–20	1(3.6%)
37–48	12(42.9%)	5(17.9%)	3 – 4	8(28.6%)	–20 to 0	7(25%)
49–60	7(25%)	1(3.6%)	5 – 6	5(17.9%)	0	2(7.1%)
61–72	3(10.7%)	6(21.4%)	7 – 8	2(7.1%)	1–20	7(25%)
73–84	0(0%)	6(21.4%)	9 – 10	2(7.1%)	21–39	8(28.6%)
85–96	0(0%)	3(10.7%)			40–49	2(7.1%)
97–108	0(0%)	0(0%)			>50	1(3.6%)
109-146	0(0%)	3(10.8%)				
Total	**27(96.4%)**	**27(96.4%)**		**28(100%)**		**28(100%)**

Source: Authors' own work

Table 4: Summary of variabilities in project costs and schedules

Change in cost (%)	Frequency (%)	Change in Schedule (%)	Frequency (%)
<–20	1(3.6%)	≤0	2(7.1%)
–20 to 0	7(25%)	1–25	9(32.1%)
0	2(7.1%)	26–50	5(17.9%)
1–20	7(25%)	51–75	5(17.9%)
21–39	8(28.6%)	76–100	2(7.1%)
40–49	2(7.1%)	101–125	3(10.7%)
>50	1(3.6%)	>125	1(3.6%)
Total	**28(100%)**		**27(96.4%)**

Source: Authors' own work

Cognitive map of causes underlying the variabilities

A cognitive map of causes underlying the variabilities are reported in Figure 1. The causes are grouped into five themes. In addition, details are given on the number of projects they impacted and how their impacts manifested in project outcomes. One of the four theme is creditor issues, in which inflation, environmental, political and economic changes caused creditors to trigger sponteneous effects on projects. **Creditor issues** were identified in 14 projects. They include *complexity in co-financing procedures*, where in 13 projects, borrowers were subjected to heavy administrative and coordination burden. *Credit approval was delayed* in 4 projects, to an average of 12.5 months. Projects' economic ecosystem had changed whilst approval delays lingered. Further, in 9 projects, *projects' funds were delayed* to an average of 10.22 months. These had caused critical liquidity issues. Payments to work contractors had slowed. Consultants were unable to attend project meetings, and project drawings were delayed. Eventually, the situation had led to major legislative changes. Evidence also suggests *payments were made by creditors erratically* in 2 projects, and this has had multiple soft impacts on project cost and shchedule. For instance, when borrowers and unsure regarding when funds will be released for projects, they are unable to provide certainty to their supply chain; when funds arrive eventually, the greater objective of the funds may not have the same vitality like when needs were met timely. In addition, *borrowers' limited experience* in bilateral were noted in 3 projects. Evidence suggests they were not familiar with lending codes, and procurement decisions had slowed. Similarly, distrust had caused them to hesitate in requesting for funds. Redesign, rescheduling and rework were significant. *Cost of finance had escalated* in 1 project, and had led to escalation of outturn costs. In addition, *terms of loan were extended* in 1 project as extra work items were added to

the original contract, causing an extension of three years to the schedule. In terms of co-relationship, it is logical to expect that delayed credit approval and release of funds, and erratic payments are related to complex finance procedures, worsened by borrowers' inexperience. Whilst major variations to projects and macroeconomic climate could justify escalations in cost of finance, there is no evidence in the data to conclude borrowers have had adequate protection against such finance market shocks and apparent exploitations that may ensure. For lenders however, they are in full control of their risk attenuation.

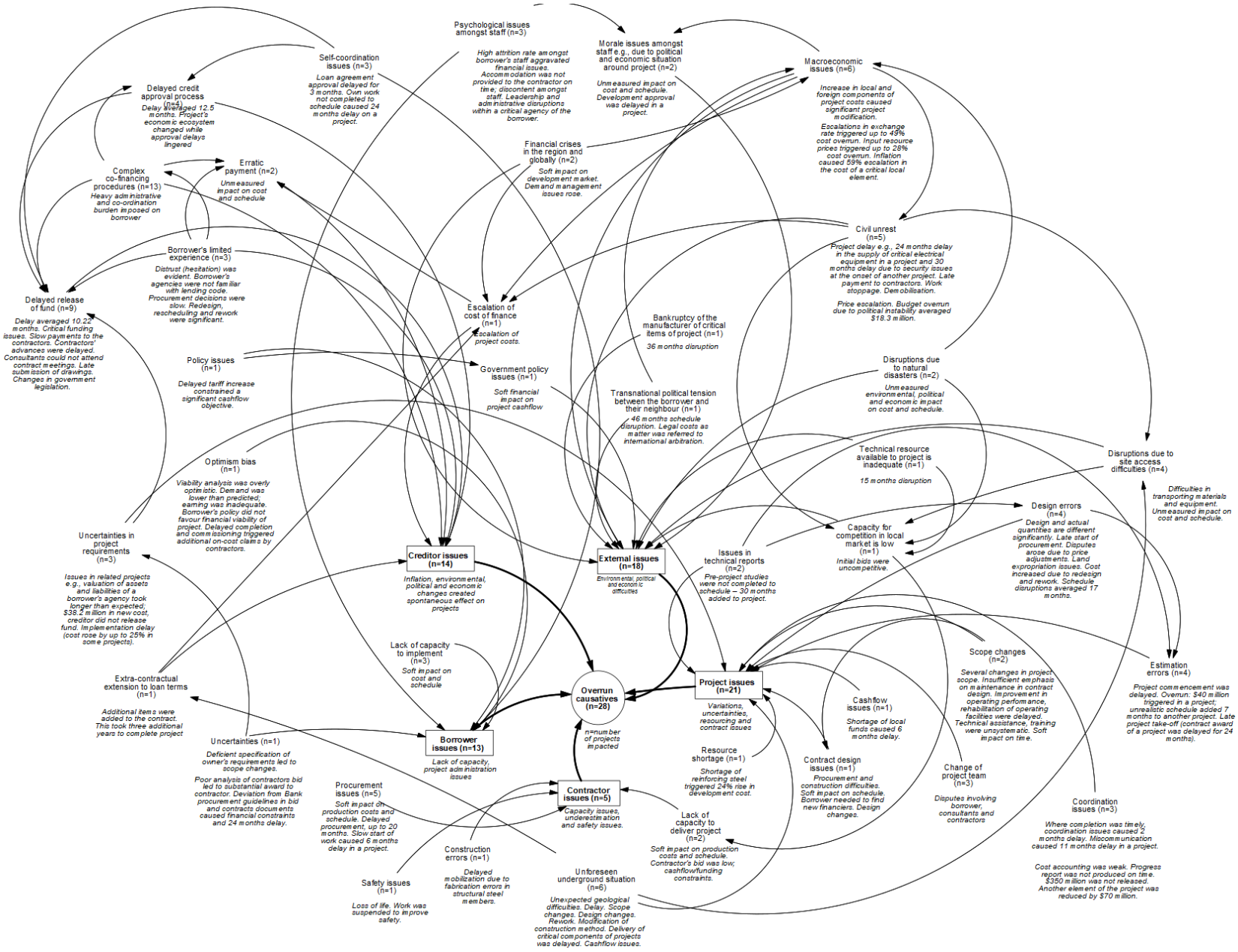


Figure 1: Cognitive mapping of overrun causations in analyzed projects.

Source: Authors' own work

External issues were another theme. They were evident in 18 projects, and had involved environmental, political and economic difficulties that occurred outside the projects but left major critical marks on the projects. For example, 6 projects have occurred while *major macroeconomic disturbances* have led to spikes in exchange rates and in the prices of resources inputs. These two triggered 49% and 28% of cost overruns respectively. Inflation also caused 59% escalation in the costs of critical local elements of projects. As local and foreign elements of projects escalated, borrowers were forced to make significant modifications to project. *Civil unrest* impacted 5 projects also. This has caused 24 months delay to the supply and delivery of critical electrical equipment in a project, and 30 months delay as security issues has meant another project could not commence. The unrests had also caused late payment to contractors, work stoppage, demobilization from site and price escalations. In the projects analysed, budget overruns due to political instabilities averaged $18.3 million. Apart from civil unrests, there were *disruptions due to access difficulties* as a result of difficult terrain in 4 project sites. Costs and schedules were impacted variously as difficulties were experienced in transporting materials and equipment to site. In addition, *natural disasters* had caused disruptions in 2 projects. They have triggered soft environmental, political and economic impacts on costs and schedules. Major *regional and global financial crises* affected 2 projects also. They caused demand management issues and several soft impacts on projects' development market. *Morale amongst staff had wanned* in 2 projects due to polical and economic situations around projects. Evidence suggest this led to delayed development approval and soft impacts on costs and schedules. In 1 project, *initial bids were uncompetitive* as capacity for competion in the local market was poor. In another project, *transnational political tension between the borrower and their neighbours* had led to 46 months

disruption, with significant legal costs as matter lingered at international arbitration. *Marked changes in government policies* triggered significant cashflow issues in 1 project. *Bankruptcy of the manufacturer* of critical items of a project had caused 36 months disruption. In another project, 15 months disruption had happened as *technical resource available to the project is inadequate*. In terms of logical relationships between causes of overruns in this theme, it is evident that macroeconomic varibailities, financial crises, psychological issues amongst staff are related to increased cost of finance, and may have been worsed by natural disasters, political tensions and civil unrests. In addition, potential for exploitation in commercial lending can be catalysed by limitations in the capacity of the local market, weak institutions necessitating reforms and limited availability of technical resources to the project. Issues with manufacturer are external unrelated event that often jeopardise MMPs.

Certain causes were also grouped as issues relating to **project attributes**. They have arisen from variabilities, uncertainties, resourcing and contract issues that were evident in 21 projects. In 6 projects, *unforeseen below-ground situations* had occurred due to unexpected geological difficulties. Delivery of critical components of projects were delayed, work scope had changed, whilst rework and modifications to planned construction methods became significant. These had led to major cashflow issues. In addition, *design errors* had impacted 4 projects. Design quantities and measured works were significantly different. These inconsistencies had led to late start of procurement. Disputes also arose due to price adjustments and land expropriation issues. Redesign and rework that arose from these caused major increase in costs, whilst the schedule disruption that ensued averaged 17 months. Major *estimation errors* also occurred in 4 projects. They triggered delayed commencement in projects. Overrun arising from this,

about $40 million in a project. Unrealistic schedule also added 7 months to another project. Estimation error also led to late take off in a project as contract award was delayed by 24 months. In 3 projects, *project teams had changed* because of disputes between borrower-owner, project designers and the contractors. Also, major *coordination issues* had occurred because cost accouting was weak and project reporting was delayed substantially. As a result, $350 million was not released by creditors. In addition, one project element was reduced by $70 million. Where completion was times, coordination issues had accounted for 2 months delay, whilst miscommunication had caused 11 months delays in another project. *Uncertainties of contract requirements* were also noted in 3 projects. Issues had arisen in a related project where valuation of assets and liabilities of one of borrower's agencies took longer than expected. As a result, $38.2 million evolved as new costs which creditors did not release. Project implementation delays were apparent in all 3 samples as cost escalated by up to 25%.

Further, 2 projects had major issues as their *technical reports were delayed* substantially – a delay in the completion of their scheduled project studies had added 30 months to a project.2 projects also reported *scope changes*. Initial design has had procurement and construction difficulties; thus, changes were made to the design. Borrower needed to find new financiers to fund new designs, and this had contributed to the overral delay reported on the project. In addition, 1 project has has *cashflow issues* as shortage of local funds caused 6 months delay in the project. In another project, development costs had risen by 24% because of *resource* (reinforcing steel) *shortage*. 1 project also reported *contract design issues*. Work scopes were changed severally as provisions made for maintenance elements in the contract were insufficient. This had led to delays in the improvement of operating performance and rehabilitation of operating facilities, whilst

technical assistance and manpower training became unsystematic. In the cognitive map shown in Figure 1, the conceptual relationship between contract design and scope changes is noted.

Borrower issues were noted as another theme of overrun causation. They were evident in 13 projects, where project administration issues are evident and borrowers had shown *limited capacity to undertake project's complexity*. In 3 projects, *psychological issues* were noted amongst borrowers' staff. Staff discontent and attrition was high, aggravating financial issues. Leadership of borrowers' critical agency also changed. *Self-coordination issues* were also reported in 3 projects. In one of the projects, contractors' bids were analysed poorly; winning bid was awarded in error. In the same project, there were significant deviations from lender's procurement guidelines, and this constrained project financially for 24 months. In another project loan agreement did not gain approval until after three months. In the third, borrower's portion of the work was not completed on schedule, and this delayed project completion by 24 months. Further, *uncertainties* impacted 1 project markedly; a deficient project specification led to major scope changes. *Policy issues* and *optimism bias* affected 1 project each also. Borrower had chosen to delay the implementation of their policy on tariff increase, and this constrained project's cashflow objectives significantly. In another instance, project's viability study was overly optimistic. Deman was lower than predicted, and earnings were inadequate. Borrower's policy did not favour the financial viability of project. In the end, delayed completion and commissioning caused additional on-cost claims by contractors.

Contractor issues were the fifth theme, reported in 5 projects in relation to capacity constraints, underestimation and compromise on safety. All 5 projects have had delayed

procurement processes of up to 20 months. Commencement of works was delayed also, addition extra 6 months to each project. Contractors lack capacity to deliver in 2 projects. Bids were low. Cashflow was problematic. Works were suspended in 1 project to deal with safety following a fatal incident. In another project, construction error was evident. Mobilization was delayed due to errors in the fabrication of structural steel members.

Identifying these factors is vitally critical. They have been sourced from actual project reports rather than academic speculations. In addition, they are specific to the ecosystem of Africa's dam projects, which are of significant economic footprint to attract international financial institutions. Thus, this cognitive analysis has helped to identify logical relationship between overrun causatives, and their transformation into causations, and their causal effects on project outcomes. For example, it is clear projects are most impacted by finance procedures, administrative issues, uncertainties, macroeconomic instabilities, borrowers' limited capacity, capacity issues within the project market and contractors' errors of judgement. Whilst these factors have been identified by frequencies and qualitative outcomes, it is important to drive the analysis further by investigating the roles of project finance in them and in project outcomes.

Causal Effects of Determinants of Project Finance on Project Outcomes

Before performing a regression analysis to identify causality between determinants of project finance and project outcomes, a correlation analysis was performed to evaluate the degree of linearity between the variables. Pearson's coefficient of correlation was calculated, shown in Table 5. The results reveal most project's contextual factors have no significant linear relationship with cost and schedule overruns, indicated as Y_{co} and Y_{so} respectively. Award budget and borrower's own fund were the main factors related to

cost overruns directly. Cost overrun had increased as they reduced. Conversely, none of the factors had a significant linear association with schedule overrun. Furthermore, there are significant linear associations between some other variables as well. Since both IDA fund and borrower's own funds are directly related to award budget, a linear model that comprises award budget as a predictor would sufficiently explain the variations observed in project outcomes. A critical part of this is in establishing causation between the two funding sources (i.e., borrowed, and own fund) and cost overrun. In addition, planned duration has a significant positive linear relationship with IDA fund, and this implies the adequacy of including only one of these two variables in a predictive model for cost overrun.

Insert Table 5

Table 5: Correlation analysis of project budget, outcome, and funding

Schedule overrun (Y_{SO})	-0.164					
Award budget (X_1)	-0.610**	0.241				
Number of lenders (X_2)	0.057	-0.030	0.346			
Planned duration (X_3)	0.076	0.323	0.241	-0.225		
IDA fund (X_4)	-0.104	-0.029	0.604**	0.188	0.506**	
Own fund (X_5)	-0.459*	0.235	0.655**	0.154	-0.075	0.166
	Y_{CO}	Y_{SO}	X_1	X_2	X_3	X_4

*Correlation is significant at 0.01**; 0.05* level.*

Source: Authors' own work

Table 6: Stepwise Regression Models

		Change Statistics		
Model	**R^2**	**R^2 Change**	**F change**	**Significance of F change**
1	0.373	0.373	14.872	0.001
2	0.472	0.099	4.478	0.045
3	0.569	0.097	5.203	0.032
4	0.672	0.103	6.870	0.016
5	0.746	0.075	6.197	0.021

Source: Authors' own work

Hierarchical regression analysis was performed on overrun indicators, Y_{co} and Y_{so}. Five variables that describe project context were used in the form of control variables, X_1 and X_2; and five causative factors of overrun as explanatory variables, Z_1–Z_5, defined in the Research Method. Stepwise method was applied whilst selecting the best set of predictors in each phase of the hierarchical regression analysis. Improvement of each modelling outcome was established by examining the significance of R^2 changes. Variance Inflation Factor (VIF) values were calculated for examining multicollinearity issues in the models. In the regression analysis, Y_{co} ran five iterations, offering significant R^2 improvement at each model (Table 6). However, only one model was fitted in the regression analysis performed on Y_{so}, as no control variables showed considerable statistical significance. Table 7 presents the two finalized regression models including their R^2 and VIF values, while the models' explanatory powers are reported in Table 8. The selected variables are fully in line with the observations of the initial correlation analysis reported in Table 5. The histograms of residuals, normal probability plots, and residual verses fitted value plots were observed for both regression models to test the validity of underlying normality and constant variability assumptions of linear regression modelling. They all confirmed satisfactory level of validity of the results.

Insert Table 6

Insert Table 7

Insert Table 8

Table 7: Results of the Hierarchical Regression Analysis

	Unstandardized Coefficients		Standardized		
	β	**Std. Error**	**β**	***p***	**VIF**
Dependent variable: $\boldsymbol{Y_{co}}$					
Constant	-3.040	4.532		0.510	
Control variables: X_{ij}					
X_1^{***}	-0.220	0.038	-0.902	0.000	2.031
X_2^{***}	2.661	0.861	0.373	0.006	1.206
X_4	0.169	0.110	0.241	0.140	2.048
Independent Variables: Z_{ij}					
Z_4^{***}	11.041	4.136	0.084	0.007	1.038
Z_5^{**}	14.422	5.793	0.085	0.010	1.244
Dependent Variable: $\boldsymbol{Y_{so}}$					
Constant	14.615	5.616		0.015	
Independent Variables: Z_{ij}					
Z_1^{**}	17.599	7.800	0.411	0.016	

*Variable is significant at *0.1; **0.05; ***0.01 level*

Source: Authors' own work

Table 8: Models' explanatory powers

	$\mathbf{Y_{co}}$	$\mathbf{Y_{so}}$
R	0.864	0.411
R^2	0.746	0.169
Adjusted R^2	0.686	0.136
p	0.000	0.033

Source: Authors' own work

As presented in Table 7, cost overrun is predicted through the model expressed in Equation 1.

$$\boldsymbol{Y_{co}} = 2.661X_2 + 0.169X_4 + 11.041Z_4 + 14.422Z_5 - 0.220X_1 - 3.040 \quad \ldots\ldots \quad \text{Equation 1}$$

The model explains 74.6% of variability in cost overruns. However, as the *p*-value of X_4 does not indicate a statistical significance. IDA fund has not had a significant influence on cost overrun directly. In addition, the negative regression coefficients in X_1 imply projects with higher award budgets have less chance of exceeding their initial budget. However, when the number of lenders is high, cost overrun is high. The standardised regression coefficients identify award budget as the most important determinant of cost overrun. Independent variables relating to borrowers and contractor issues are the most significant causes of cost overruns. Issues related to creditors, country's socio-political factors, and projects seem to have limited statistically significance on cost performance.

Model to predict schedule overrun is given in Equation 2. As the model expresses a low R^2, it would not predict $\boldsymbol{Y_{so}}$ adequately. However, the model is useful to identify the effect of project background variables and issues on project schedule. Accordingly, none of the control variables, namely: project's award budget, number of lenders, planned duration, IDA fund and borrowers own fund had significant effect on schedule overrun. The only factor that caused schedule overrun is creditor issues.

$$\boldsymbol{Y_{so}} = 14.615 + 17.599Z_1 \quad \ldots\ldots \quad \text{Equation 2}$$

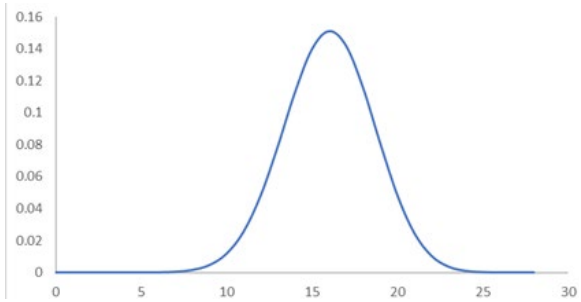
Sample Probabilities of Cost and Schedule Overruns

In addition to causal analyses on project variables, conditional probabilities of cost overruns were explored using each of the causal factors. Whilst 25 projects (89% of samples) had schedule overruns, 18 projects (65%) had cost overruns. Table 9 shows the calculated sample probabilities for cost overruns. These values clearly indicate the greater chance of cost overrun in projects that have been impacted by any of the causation factors – creditor issues, external issues, project attributes, borrower issues, and contractor issues. Causalities of each of the factors are presented in the form of probability curves shown in Figure 2. Minitab software was used to calculate the binomial probabilities of the number of projects with a cost overrun under the condition of each causal factor. Both Table 9 and Figure 2 confirm that borrower-related issues, external issues and contactor issues were the prominent causes of cost overrun in the projects analysed in this study. The statistical significance of external issues was not supported by findings from the regression analysis – this is likely caused by sample limitations triggered by variations of project characteristics. Apparently, there is a considerable chance that external issues also lead to significant cost overruns in projects.

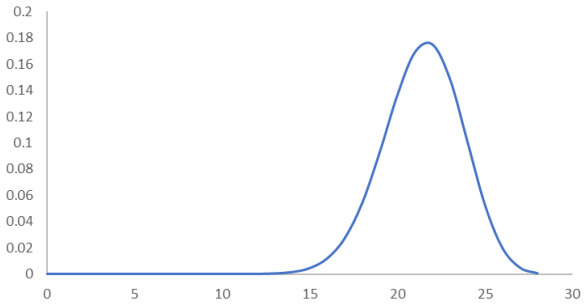
Table 9: Sample Conditional Probabilities of Cost Overrun

Conditional probability of cost overrun	**Probability**
Pr(Creditor issues, Z_1)	0.571
Pr(External issues, Z_2)	0.765
Pr(Project attribute issues, Z_3)	0.600
Pr(Borrower issues, Z_4)	0.846
Pr(Contractor issues, Z_5)	0.750

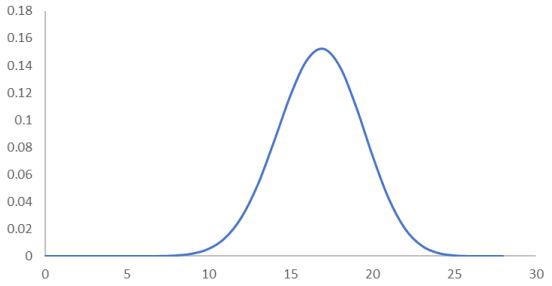
Source: Authors' own work



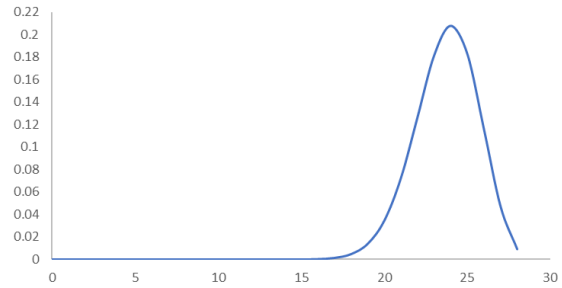
(a) Pr(Creditor issues, Z_1)



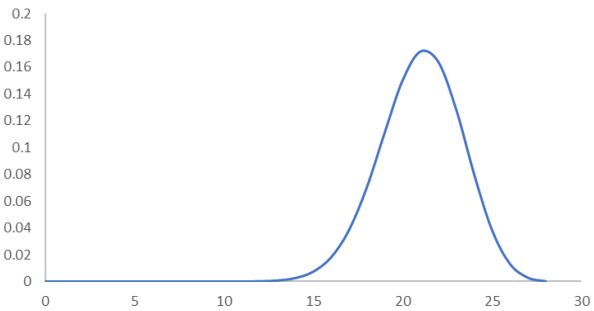
(b) Pr(External issues, Z_2)



(c) Pr(Project attribute issues, Z_3)



(d) Pr(Borrower issues, Z_4)



(e) Pr(Contractor issues, Z_5)

Figure 2: Probability curves of cost overruns

Source: Authors' own work

Discussion

One central thesis of this study is that there are interconnected elements in how project finance shape project outcomes, and that these elements, grouped into five themes, interract like an ecosystem, as independent elements in a form of complex relationship. The context of complexity contextualised in this study is such that the interractions between elements of project finance and project outcomes are non-linear. Findings from this study clarify in part how overruns occur in projects. They show causations of overruns are beyond contractors' deliberate mis-representation or estimators' delusion as claimed by Flyvbjerg et al. (2018), rather by factors that neither party could control. For example, it is evident in the study that creditor issues are a dominant cause of delays. This is because attitudes of the creditors analysed in the study show business behaviours that are strict, firm, controlling and are abhorrent to project risk. Project owners who borrow for development, and their contractors, are vulnerable to this, just as they are also vulnerable to other causal factors such as complex externalities and risks that are inherent in projects. On the one hand, it is convenient to argue that creditors are as vulnerable to external events and project risks as borrower-owners and their contractors, however international creditors analysed in this study are notable actors with significant knowledge and capacity to simplify difficulties and predict their outcomes. Recent public enquiries in developed economies have shown how creditors use their business advantage as predatory and exploitative e.g., see report of the Financial Crisis Inquiry Commission (2011) of the United States of America and Hayne's (2019) Royal Commission's investigation into misconducts in Australian banking, superannuation and finance services industry. One key finding in these reports is that it is inappropriate to

undertake commercial lending to parties whose capacity to borrow is a major risk. In all the cases analysed in this study, 86% had 0% of own finance in project funds.

Majority of overruns had occurred because credit approval processes and fund release were delayed against borrowers' expectation. Further delays have occurred in the course of project execution due to administrative inadequacies in borrowers' capacities. In addition, as macro-economic issues, civil unrests and natural disasters add their layer of complexity, finance costs had escalated. The study also found contract designs, contingencies, variabilities, misleading project studies and unstable government policies had triggered significant cashflow issues. Several studies have theorized these factors individually. For example, Akintoye and Skitmore (1993) explain how unemployment level in the economy, interest rate, exchange rate and work stoppages do trigger cost escalations in projects. In addition, Olatunji (2018) have reported on the impact of war on projects in Africa, whilst Olatunji *et al.,* (2018) have reported on the effects of unstable price movements in Africa's construction market on budget predictions. Seeking to explore the impact of these variables individually can only lead to a partial understanding of the complex situation underlying overrun causations. One step taken further by this study is to elicit how projects react to a combination of these factors, in the same environment, where project types and contract situations are comparable.

Findings suggest cost overruns had reduced where award budget was high, and where borrowers had owned a considerable portion of their project fund. Whilst borrowers' own funds give them opportunity to smoothen project cashflows and arrest price movements, relationship between award budget and cost overruns can be explained in various ways. One way is to look at this from the point of view of behavioural issues as noted by various authors, such as strategic misrepresentation and optimism bias articulated by Flyvbjerg

(2021), bid unbalancing methods such as front loading (Cattell, Bowen and Kaka, 2007), ethical issues (Signor et al. 2020) or estimation error (Cantarelli et al. 2012). However, beyond these, it is also important to consider the constraining role of project finance. As uncertainties trigger negative indicators in projects, it is only incumbent for stakeholders to redesign and modify work scopes and methods to achieve different (cheaper) cost outcomes. Such outcomes are rather about building to firm budgets, not necessarily about keeping to the projects' original cost objectives. Even where additional finance has been made available, overall project value may not have benefitted. Another way to look at this is reference points where overruns are calculated from, and how they are calculated. For example, Love et al. (2015) explain how overruns are calculated in reference to different project stages. Where actual costs are compared to feasibility cost plans or predesign budgets, outcome from them will be different to where they are compared to firm post-design project estimates. In the case of the project analysed in this study, original reference points were pre-award budget points when actual project considerations have not been concluded. Moreover, overruns are calculated in comparison to original contract amount. For illustration, where a $500 million project overruns its budget by $100 million, overrun is 20%; whereas if a $10 million project overruns its budget by $5 million, the overrun is 50%. Both cases may have been caused by the same factor e.g., disruptions due to exchange rate issues. Whilst actual portion of overrun in the large ($500 million) project is much higher than the example of small ($10 million) project given – i.e., $100 million versus $5 million, an unintended impression is given when such overruns are compared in percentages. The 20% in the example of large project given will appear smaller to the 50% given in the example of the smaller project's. This does not mean overruns are less in large projects than they are in small projects.

Another major finding in this study is the relationship between schedule and cost overruns, and project finance variables. Although the explanatory powers are weak, the regression model developed in this study shows creditor issues are the most critical causes of schedule overruns. Whilst schedule overruns have considerable implications that should translate into add-on costs, there is significant evidence in the weak of correlation between schedule and cost overruns. Delays are caused by creditors; however, they cannot be held to account for this in project contracts. Creditors occupy a 'kingly' position; borrower-owners and projects are the vulnerable parties, and the true price to pay is for their vulnerability is to endure their creditors' burden. This is an understanding of risks that project contractors under the circumstances of project finance analysed in this study would have and compensate for as they put their estimates together. Thus, whilst it may not be contractors' intention to misrepresent, complexities of project finance warrant reasonable provisions for variabilities that may arise because of causes that are beyond the immediate project environment.

Conclusions

This study explored causal relationships between cost and schedule outcomes of major and mega projects and project owners' vulnerabilities to project financing. Elements of creditors' opportunism and exploitative conducts provided appropriate window to explore project finance issues. Africa has had established history regarding capacity issues, a high development risk appetite and significant credit exposures. A total of 28 major dam projects in Africa funded by the 10 major international funding agencies were identified and analysed from project completion reports published by the World Bank. Analysis focused on the effects of project characteristics such as award budget, number

of lenders, planned duration, IDA fund and the proportion of borrower's own fund in project estimates on project outcomes – measured only in terms of project costs and schedules. In addition, creditor issues, external issues, project attributes, borrower issues and contractor issues were identified and analysed. Whilst results show most project contextual factors have limited linear relationships with cost and schedule performance, evidence was conclusive on the effects of award budget and proportion of borrower's own fund in project estimates on cost overruns, and the role of creditor issues in project delays and outturn cost value of projects. Delays are inimical to firm estimates upon which finance contracts are based. Simiarly, macro-economic issues, procurement issues, civil unrests and procurement issues contribute to overruns frequently also. They are often more prominent than estimation errors, design errors and project management issues. In addition, evidence was conclusive on the relationship between lender attributes and project outcomes *e.g.,* amount of IDA's fund and number of lenders could predict cost overrun. It is also clear from the study that borrower issues [*e.g.,* inadequate capacity to deal with financing risks], external issues [*e.g.,* financing risks and external political influences] and contactor issues [e.g., technical capacity issues and management limitations] are the most critical problems behind project performance issues in Africa. The additionality of this contribution is for the research community to look beyond contractors' deception and clients' optimism in the face of uncertainties as the main elements of behavioural science to draw from when considering causations of project overruns. Findings from this study could have been different if a larger number of projects were available for analysis. In addition, outcomes could differ by country, project types, regions, lender-types, era, procurement methods and perspectives of other stakeholders [in addition to a single lender's untested report]. The predictive models presented in the

study have not been tested either. Nonetheless, these limitations do not take away from the integrity of the study; in that, the 28 projects analysed represent a significant proportion of major dam projects in Africa. Analysis had maintained consistency with project type, creditors, and procurement method. Not least, all the limitations are capable of triggering insights for further research.

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