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Evaluating Cost Estimation and Budgeting Challenges in Public Health and Education Infrastructure Projects

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Abstract

Persistent cost overruns and budgetary deviations continue to undermine the delivery of public infrastructure projects worldwide, despite decades of reform in project management and public financial management systems. While extensive scholarship has examined cost estimation failures in large transportation and energy megaprojects, comparatively limited attention has been paid to public health and education infrastructure, sectors that are central to human capital development and social welfare. This paper addresses this gap by critically evaluating cost estimation and budgeting challenges in public health and education infrastructure projects from a global perspective.

Drawing on a comprehensive synthesis of international fiscal data, infrastructure performance studies, and institutional analyses, the study examines how macro-fiscal constraints, budget allocation frameworks, and governance arrangements shape cost estimation practices and project cost performance in hospitals, schools, and higher education facilities. The paper develops an integrated conceptual framework linking fiscal structures, budget rigidity, behavioral biases, and institutional capacity to systematic underestimation and subsequent cost escalation. Empirical evidence from global datasets and sector-specific studies reveals that cost overruns in health and education infrastructure are pervasive across income groups, with average overruns frequently exceeding 20–40%, reflecting structural rather than context-specific failures.

The findings demonstrate that cost estimation inaccuracies are not merely technical errors but are deeply embedded in political and institutional incentive systems that prioritize project approval over delivery realism. By explicitly connecting cost estimation processes to public budgeting mechanisms, the study advances infrastructure governance theory beyond project-level explanations. The paper concludes by outlining policy-relevant implications for improving estimation accuracy, strengthening budget credibility, and enhancing value for money in public health and education infrastructure investment.

Keywords: cost estimation, budgeting, cost overruns, public infrastructure, health infrastructure, education infrastructure, public investment management

Introduction.

Public investment in health and education infrastructure has become a defining feature of development strategies across both advanced and emerging economies. Hospitals, clinics, schools, and universities are widely recognized as foundational assets for economic productivity, social equity, and resilience to demographic and public health shocks. Governments have consequently

expanded capital spending on social infrastructure over the past two decades, particularly in response to rapid urbanization, population growth, and the COVID-19 pandemic. Yet, despite this expansion, the delivery of public health and education infrastructure projects remains persistently plagued by cost overruns, budget reallocations, and delays, raising critical questions about the effectiveness of prevailing cost estimation and budgeting practices.

Cost overruns are not merely accounting discrepancies; they represent systemic failures with tangible consequences for public service delivery. When infrastructure projects exceed their approved budgets, governments are forced to divert resources from other priorities, reduce project scope, compromise quality, or delay completion. In health infrastructure, such outcomes can affect patient safety, clinical capacity, and long-term operational sustainability. In education infrastructure, they may translate into overcrowded classrooms, deferred maintenance, or reduced access to learning facilities. Understanding why cost estimation and budgeting failures persist in these sectors is therefore essential not only for fiscal discipline but also for achieving broader social policy objectives.

The academic literature on infrastructure cost overruns has grown substantially, yet it remains heavily skewed toward transportation and energy megaprojects. While this body of work has generated valuable insights into optimism bias, strategic misrepresentation, and governance failures, its applicability to public health and education infrastructure is not straightforward. Social-sector projects differ in important respects: they are rarely revenue-generating, are subject to intense political and social pressure, and often involve complex regulatory, technological, and stakeholder environments. These characteristics suggest that cost estimation and budgeting challenges in health and education infrastructure may follow distinct dynamics that warrant dedicated analysis.

At the same time, public health and education infrastructure projects operate within national budgeting systems that impose rigid fiscal constraints and prioritize short-term affordability over long-term realism. Medium-term expenditure frameworks, annual budget cycles, and debt sustainability rules shape how projects are appraised and approved, often encouraging cost estimates that conform to available fiscal space rather than empirically grounded risk-adjusted forecasts. This interaction between cost estimation and budgeting systems remains underexplored in the existing literature, which tends to treat estimation accuracy as a technical project management issue rather than as an outcome of institutional design.

This paper responds to these gaps by evaluating cost estimation and budgeting challenges in public health and education infrastructure projects through an integrated analytical lens. Rather than focusing on individual project failures, the study examines systemic drivers that operate across countries and sectors, combining insights from project management, public finance, behavioral economics, and infrastructure governance. By explicitly linking cost estimation practices to budget allocation frameworks, the paper advances a more holistic understanding of why underestimation persists and why reform efforts have yielded limited success.

The paper makes three primary contributions to the literature. First, it extends cost overrun research beyond its traditional focus on transport and energy megaprojects by providing a sector-specific analysis of public health and education infrastructure, supported by global evidence. Second, it develops a conceptual framework that integrates fiscal structures, budgeting processes, behavioral biases, and institutional capacity, offering a more comprehensive explanation of estimation and budgeting failures. Third, it derives policy-relevant insights that highlight the need for reforms targeting incentive alignment and institutional design, rather than relying solely on improved technical estimation methods.

Literature review:

The problem of inaccurate cost estimation and persistent budgeting failures in public infrastructure projects has attracted sustained scholarly attention for more than four decades. Despite methodological advances in project management, forecasting techniques, and public financial management, empirical evidence continues to show that public projects systematically exceed their

initially approved budgets. This reviews the evolution of this literature, synthesizing insights from project management, public finance, behavioral economics, and infrastructure governance, with a specific focus on public health and education infrastructure. It highlights established explanations, evaluates their limitations, and identifies gaps that motivate the present study.

Early project management scholarship conceptualized cost estimation as a technical forecasting activity, grounded in engineering economics and quantitative planning methods (Morris & Hough, 1987; Kerzner, 2017). Techniques such as unit cost estimation, analogous estimation, and parametric modeling were assumed to yield increasingly accurate forecasts as data availability and computational tools improved. Within this paradigm, estimation errors were largely attributed to inadequate information, poor technical competence, or immature planning processes (PMI, 2021).

However, comparative empirical research challenged these assumptions. Large datasets revealed that cost estimation errors in public infrastructure projects were systematic rather than random, exhibiting a consistent downward bias (Flyvbjerg, Holm, & Buhl, 2002; Flyvbjerg, 2014). These findings undermined purely technical explanations and prompted a shift toward institutional and political interpretations.

Public budgeting scholars further advanced this shift by emphasizing that cost estimates are produced within politicized budgeting environments rather than neutral analytical settings (Wildavsky, 1986; Rubin, 2016). Budgeting processes are shaped by fiscal ceilings, inter-ministerial competition, and political bargaining, all of which influence how cost information is generated and presented. Schick (2014) argues that modern public budgeting systems prioritize aggregate fiscal control over allocative efficiency, creating incentives to compress project costs to fit predefined expenditure envelopes.

In this institutional context, cost estimation and budgeting are not sequential steps but mutually constitutive processes. Estimates shape budget decisions, while budgets retrospectively shape estimates. This interdependence is especially pronounced in public health and education infrastructure, where projects are politically sensitive, non-revenue-generating, and subject to rigid expenditure controls (IMF, 2018; OECD, 2020).

The empirical foundation of the cost overrun literature rests on large-scale comparative studies. Flyvbjerg et al. (2002) analyzed hundreds of public infrastructure projects and found average cost overruns of 28% for transport projects, with similar patterns observed in other sectors. Subsequent expansions of this dataset confirmed that between 80% and 90% of projects exceed their initial budgets, with little evidence of improvement over time (Flyvbjerg, 2014; Flyvbjerg, 2018).

Meta-analyses reinforce these conclusions. Cantarelli et al. (2012) demonstrate that cost overrun distributions are heavily right-skewed, indicating that extreme overruns, while less frequent, impose disproportionate fiscal burdens. Love, Ahiaga-Dagbui, and Irani (2016) show that even projects delivered under modern procurement arrangements continue to experience systematic cost escalation.

Importantly, the literature increasingly documents that social infrastructure projects are no exception. World Bank (2019) evaluations of hospital construction projects report average cost overruns ranging from 25% to 40%, driven by underestimated equipment costs, regulatory compliance, and design changes. WHO (2019) similarly identifies chronic underestimation in health facility planning, particularly in low- and middle-income countries but also in advanced economies.

Education infrastructure projects exhibit comparable patterns. UNESCO (2021) and OECD (2021) document persistent underestimation in large-scale school construction and university expansion programs, with cost overruns frequently linked to land acquisition delays, inaccurate enrollment forecasts, and neglected lifecycle costs. These findings challenge assumptions that social infrastructure projects are inherently less risky than transport or energy megaprojects.

Cross-country evidence further demonstrates that cost overruns are not confined to weak institutional contexts. Studies show that high-income OECD countries experience systematic underestimation, albeit with lower variance and more robust corrective mechanisms (OECD, 2020; Flyvbjerg, 2014). This universality suggests that cost overruns are structural features of public investment decision-making rather than anomalies attributable to local capacity constraints.

Behavioral economics provides one of the most influential explanations for systematic cost underestimation. Kahneman and Tversky's (1979) prospect theory and subsequent work on the planning fallacy highlight cognitive tendencies toward overconfidence and insufficient consideration of adverse outcomes. Lovallo and Kahneman (2003) apply these insights to strategic decision-making, arguing that planners focus on internal project scenarios rather than external empirical evidence.

Empirical studies support the relevance of optimism bias in infrastructure planning. Flyvbjerg (2008) demonstrates that planners consistently ignore historical cost distributions, even when such data are readily available. In public health infrastructure, technological complexity and evolving clinical standards amplify uncertainty, making optimistic assumptions particularly attractive (Locatelli et al., 2020; WHO, 2019). In education infrastructure, optimism bias often manifests in demographic and enrollment projections, which are treated as deterministic despite high volatility (UNESCO, 2021).

However, the behavioral literature faces a critical limitation: it struggles to explain the absence of learning effects. If optimism bias were purely cognitive, repeated forecasting failures should lead to improved accuracy over time. The persistence of underestimation across decades suggests that behavioral biases are reinforced, rather than corrected, by institutional environments.

To address this limitation, scholars have emphasized strategic misrepresentation as a complementary explanation. Wachs (1989) first documented deliberate cost underestimation in transportation planning, arguing that planners manipulate forecasts to advance preferred projects. Flyvbjerg et al. (2002) formalize this argument, framing underestimation as rational behavior within political systems that reward project approval but weakly sanction delivery failure.

Empirical evidence supports this perspective. Projects competing for limited capital funds exhibit stronger incentives to present optimistic estimates (Siemiatycki, 2015). Once approved, projects gain political momentum, making cancellation or radical redesign unlikely even when costs escalate (Merrow, 2011; Flyvbjerg, 2018). This dynamic creates what has been described as a "lock-in" effect, where early decisions constrain later options.

Public health and education infrastructure projects are particularly vulnerable to strategic misrepresentation due to their symbolic value. Hospitals and schools serve as visible indicators of government commitment to welfare and development, making rapid approval politically advantageous (IMF, 2018; OECD, 2020). The delayed and diffuse nature of cost overruns further weakens accountability, allowing strategic underestimation to persist across electoral cycles.

Public financial management research highlights the role of budget rigidity in perpetuating estimation bias. Medium-term expenditure frameworks, fiscal rules, and debt sustainability constraints are designed to enhance discipline but often impose hard capital ceilings that are poorly aligned with project-level risk (Schick, 2014; IMF, 2018). As a result, cost estimates are frequently adjusted to fit budgets rather than budgets being adjusted to reflect realistic costs.

In low- and middle-income countries, donor financing introduces additional complexity. While multilateral and bilateral donors often require rigorous appraisal, fixed financing envelopes and disbursement conditions limit flexibility when costs exceed estimates (World Bank, 2019; Asian Development Bank, 2020). Empirical studies show that such rigidity often results in scope reductions, quality compromises, or delayed completion, particularly in health and education projects (UNESCO, 2021).

Governance quality moderates but does not eliminate cost estimation bias. Stronger institutions are associated with lower average overruns and more effective corrective mechanisms, yet underestimation persists even in high-capacity settings (World Bank, 2020; Flyvbjerg, 2014). Procurement systems play a central role in translating estimation errors into cost escalation. Non-competitive procurement, weak contract management, and poor risk allocation are consistently linked to overruns (OECD, 2021; Love et al., 2019).

Capacity constraints further exacerbate these challenges. Shortages of skilled estimators, engineers, and project managers limit the ability of public agencies to model uncertainty effectively, particularly

in complex hospital projects (WHO, 2019). Education infrastructure projects face coordination challenges arising from dispersed sites and fragmented governance structures (UNESCO, 2021).

Despite extensive research, three gaps remain salient. First, social-sector infrastructure—particularly health and education—remains underrepresented relative to transport and energy megaprojects. Second, the interaction between cost estimation practices and public budgeting systems remains insufficiently theorized. Third, comparative analysis across health and education sectors is limited, despite their shared fiscal and political characteristics.

This study addresses these gaps by integrating cost estimation theory with public budgeting analysis in a global, comparative examination of public health and education infrastructure projects.

This qualitative–analytical research design grounded in systematic literature synthesis and comparative institutional analysis to evaluate cost estimation and budgeting challenges in public health and education infrastructure projects. Given the global scope of the research question and the study's emphasis on structural, institutional, and behavioral mechanisms, the methodology is designed to integrate evidence from multiple sources rather than rely on single-country or project-level primary data. This approach is consistent with established practices in high-impact infrastructure governance and public finance research, where secondary data and cross-sectoral synthesis are commonly employed to examine systemic patterns and causal mechanisms.

The research follows an explanatory and integrative design aimed at identifying and evaluating the mechanisms through which cost estimation inaccuracies and budgeting failures arise and persist. Rather than testing a single causal hypothesis using econometric methods, the study seeks to explain a well-documented empirical regularity—systematic cost underestimation and subsequent cost overruns—by synthesizing insights across disciplines and sectors. This design aligns with prior influential studies in infrastructure research that emphasize theory-building and mechanism-based explanation over narrow statistical inference.

The analytical orientation is informed by three complementary theoretical lenses: public investment management theory, behavioral decision-making theory, and institutional governance theory. Public investment management theory provides a framework for understanding how fiscal rules, budgetary institutions, and capital allocation processes shape project appraisal and approval. Behavioral decision-making theory contributes insights into optimism bias, the planning fallacy, and bounded rationality in forecasting. Institutional governance theory highlights how incentive structures, accountability mechanisms, and organizational capacity influence estimation behavior and project outcomes. Together, these perspectives support a multi-level analysis that links macro-fiscal conditions to project-level cost performance.

The study draws on an extensive body of secondary data and documentary evidence from authoritative international sources and peer-reviewed academic literature. Key data sources include global fiscal datasets and analytical reports published by the International Monetary Fund, World Bank, Organisation for Economic Co-operation and Development, World Health Organization, and UNESCO. These sources provide comparative information on public expenditure patterns, capital budget execution, and infrastructure performance across countries and income groups.

In addition to institutional data, the analysis incorporates evidence from large-scale empirical studies on infrastructure cost overruns, sector-specific evaluations of health and education infrastructure projects, and meta-analyses published in leading journals such as International Journal of Project Management, Project Management Journal, Construction Management and Economics, and World Development. Project-level findings reported in evaluation reports and academic case studies are used selectively to illustrate broader patterns rather than to generalize from individual cases.

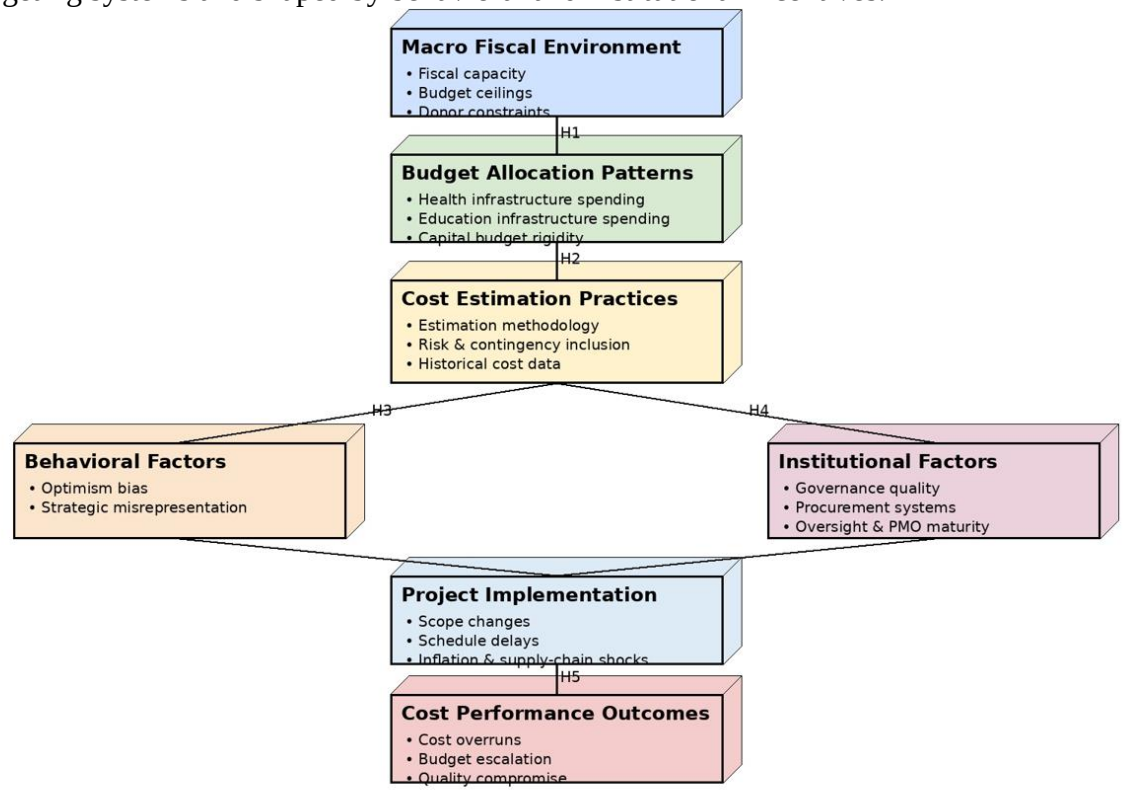
The analysis proceeds in three structured stages. First, the literature is systematically reviewed to identify recurring themes, explanatory variables, and empirical regularities related to cost estimation accuracy and budgeting performance. Particular attention is paid to how different strands of literature conceptualize the relationship between estimation practices and budgeting systems, and to the extent to which health and education infrastructure are explicitly addressed.

Second, the identified drivers are analytically classified into four broad categories: fiscal and budgetary structures, behavioral and cognitive factors, institutional and governance arrangements, and project-specific characteristics. This classification is not intended as a rigid taxonomy but as an analytical device to clarify causal pathways and interactions. Evidence from multiple sources is triangulated to assess the relative importance and interaction of these drivers across contexts.

Third, comparative analysis is conducted between public health and education infrastructure sectors. While recognizing heterogeneity within each sector, the analysis identifies commonalities and differences in cost estimation challenges, budgetary constraints, and implementation risks. This comparative dimension enhances the study's contribution by demonstrating how sectoral characteristics interact with shared institutional environments.

Throughout the analysis, emphasis is placed on identifying mechanisms rather than merely correlating variables. This mechanism-oriented approach strengthens causal plausibility and aligns with contemporary expectations in qualitative and mixed-methods infrastructure research.

Building on the literature review and analytical synthesis, the study develops an integrated conceptual framework that links macro-level fiscal conditions, budget allocation patterns, and governance arrangements to cost estimation practices and project cost performance. The framework conceptualizes cost estimation not as an isolated technical activity but as a process embedded within budgeting systems and shaped by behavioral and institutional incentives.



At the macro level, fiscal capacity, budget ceilings, and external financing constraints influence how resources are allocated to health and education infrastructure. At the meso level, budgeting frameworks and institutional arrangements shape estimation practices, including the treatment of risk and uncertainty. At the micro level, behavioral factors and project-specific complexities influence implementation dynamics, leading to cost escalation when initial estimates prove unrealistic. Cost performance outcomes, including cost overruns and scope adjustments, are thus understood as emergent properties of interactions across these levels.

The conceptual framework serves two primary purposes. Analytically, it provides a structured lens for interpreting the empirical evidence reviewed. Methodologically, it offers a basis for formulating

hypotheses and guiding future empirical research, including quantitative testing and case-based validation.

Several strategies are employed to enhance the rigor and credibility of the analysis. First, triangulation across multiple data sources and disciplinary perspectives reduces the risk of bias associated with reliance on a single dataset or theoretical lens. Second, explicit attention to sectoral comparison strengthens external validity by demonstrating that identified mechanisms operate across different types of social infrastructure. Third, transparency in the analytical classification and synthesis process allows readers to assess the plausibility of the study's interpretations.

Nevertheless, the study has limitations. As a synthesis-based analysis, it does not generate new primary data or statistically test causal relationships. While this limits the ability to make probabilistic claims, it is appropriate given the study's objective of explaining systemic patterns at a global level. The conceptual framework is intended as a heuristic and analytical tool rather than a definitive causal model, and its propositions should be tested in future empirical research using project-level datasets and mixed-method approaches

Cost estimation and budgeting challenges in public health and education infrastructure projects must be understood within the broader context of global public investment patterns. Project-level cost overruns are shaped not only by technical or managerial factors but also by macro-fiscal conditions, budgetary priorities, and institutional constraints that influence how projects are appraised and approved. This integrates global evidence on budget allocation patterns with sector-specific cost overrun data to establish the empirical context for the subsequent analytical examination of drivers.

Global data indicate that while public spending on health and education has increased over the past two decades, capital investment in infrastructure constitutes a relatively small and often volatile share of total sectoral expenditure. Across income groups, recurrent expenditures—particularly wages, pharmaceuticals, and operational costs—dominate health and education budgets, leaving limited fiscal space for new infrastructure development or major rehabilitation.

As shown in Table 1, high-income OECD countries typically allocate between 0.8% and 1.5% of GDP to health infrastructure and between 0.6% and 1.2% to education infrastructure. Although these levels are substantially higher than those observed in lower-income contexts, capital investment still represents a modest proportion of total sectoral spending. In low- and lower-middle-income countries, infrastructure investment frequently falls below 0.5% of GDP in both sectors, reflecting constrained fiscal capacity, high debt burdens, and competing development priorities.

Table 1 also highlights two structural features with direct implications for cost estimation accuracy. First, capital budget execution rates are consistently lower than those for recurrent expenditure, particularly in lower-income countries where execution rates often fall below 70%. Second, capital budget rigidity—characterized by fixed expenditure ceilings, limited contingency provisions, and inflexible medium-term expenditure frameworks—is most pronounced in contexts with the greatest infrastructure needs. These conditions create strong incentives for project proponents to align cost estimates with available fiscal space rather than with realistic assessments of uncertainty and risk.

Table 1. Global public budget allocation to health and education infrastructure

Region / Income Group	Health Infrastructure Investment (% of GDP)	Education Infrastructure Investment (% of GDP)	Capital Budget Execution Rate (%)	Capital Budget Rigidity	Key Sources
High-income (OECD)	0.8 – 1.5	0.6 – 1.2	85 – 95	Medium	OECD (2020, 2024); IMF (2018)
Upper-middle income	0.5 – 1.0	0.4 – 0.9	70 – 85	High	World Bank (2023); IMF (2019)

Region / Income Group	Health Infrastructure Investment (% of GDP)	Education Infrastructure Investment (% of GDP)	Capital Budget Execution Rate (%)	Capital Budget Rigidity	Key Sources
Lower-middle income	0.3 – 0.7	0.3 – 0.6	60 – 75	High	World Bank (2022); UNESCO (2021)
Low-income	<0.3	<0.3	50 – 65	Very High	World Bank (2023); WHO (2019)

4.2 Temporal dynamics and fiscal volatility in infrastructure investment

The temporal dimension of public investment further compounds cost estimation challenges. Capital spending on health and education infrastructure is highly sensitive to macroeconomic conditions and fiscal cycles. During periods of economic expansion, governments tend to increase infrastructure investment, while fiscal downturns often result in abrupt reductions or postponements of capital projects.

This pattern is illustrated in Figure 2, which shows global trends in public investment in health and education infrastructure between 2000 and 2023. The figure demonstrates pronounced procyclicality, with capital investment declining sharply during periods of fiscal stress, including the global financial crisis and the COVID-19 pandemic. Such volatility undermines estimation accuracy by increasing uncertainty regarding future funding availability, while budgetary rigidity discourages explicit recognition of these risks in early project appraisal.

Figure 2. Global trends in public investment in health and education infrastructure (2000–2023)

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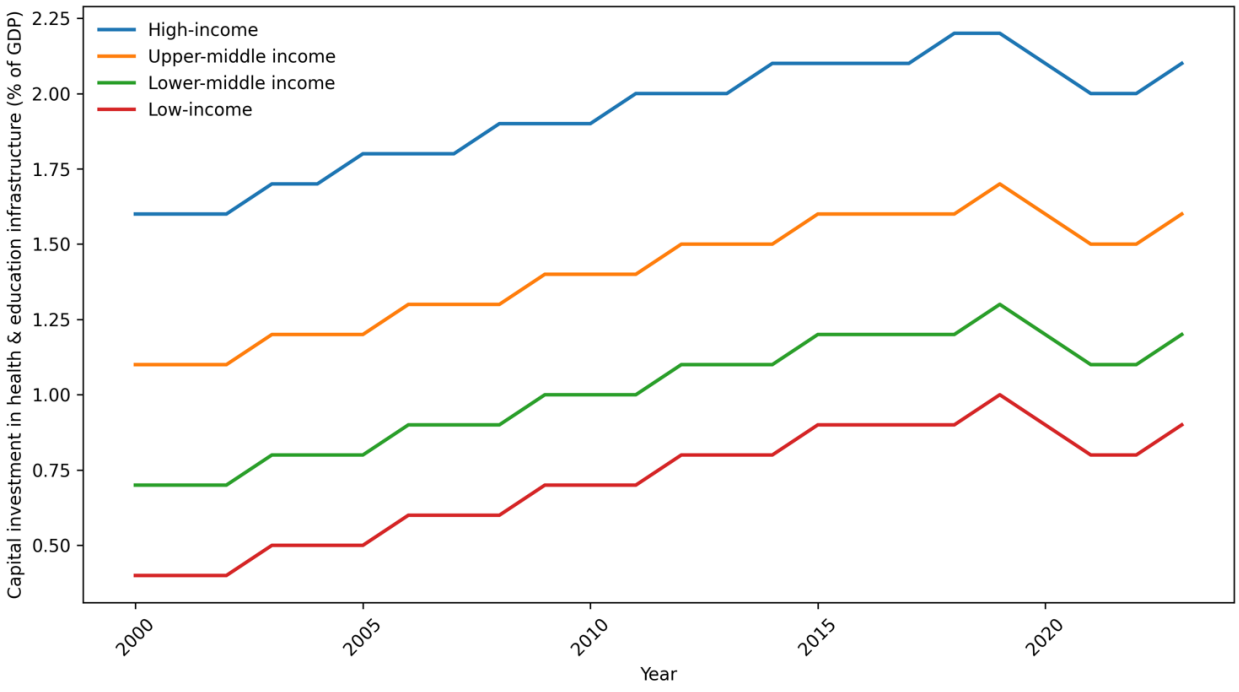

Line graph depicting capital investment in health and education infrastructure as a percentage of GDP, disaggregated by income group.

Cost overrun evidence in public health and education infrastructure projects

Against this budgetary backdrop, cost overruns emerge as a persistent and predictable feature of public health and education infrastructure delivery. International evidence consistently shows that

the majority of projects in both sectors exceed their initially approved budgets, often by substantial margins. These overruns are not isolated anomalies but reflect systematic underestimation at the appraisal stage.

Table 2 synthesizes reported cost overrun statistics for health and education infrastructure projects across regions. Hospital construction projects exhibit particularly high average overruns, typically ranging from 25% to 40%, with extreme cases exceeding 100% of original estimates. These outcomes are driven by underestimated medical equipment costs, regulatory compliance requirements, late-stage design changes, and procurement complexities. The technical and organizational complexity of hospital projects makes early-stage cost forecasting especially challenging.

Education infrastructure projects generally exhibit lower average overruns, typically between 15% and 30%, yet the direction of bias remains consistently upward. Large-scale school construction programs and university campus developments are especially vulnerable to cost escalation arising from land acquisition delays, inaccurate enrollment projections, inflation in construction inputs, and inadequate allowance for lifecycle costs.

Table 2. Reported cost overrun statistics in public health and education infrastructure projects

Sector	Project Type	Average Cost Overrun (%)	Maximum Reported Overrun (%)	Geographic Coverage	Key Sources
Health	General hospitals	25 – 40	>100	Global	Flyvbjerg (2014); WHO (2019); World Bank (2019)
Health	Specialized hospitals	30 – 60	>120	Global	Locatelli et al. (2020); OECD (2021)
Education	Primary & secondary schools	15 – 30	70 – 90	Global	UNESCO (2021); OECD (2021)
Education	Universities & campuses	20 – 35	>80	Global	World Bank (2020); Love et al. (2019)

Sectoral comparison and distributional patterns

While health infrastructure projects tend to exhibit higher average cost overruns, the distribution of overruns across sectors reveals substantial overlap. As illustrated in Figure 3, both health and education projects display wide dispersion around their mean values, indicating that severe overruns are not confined to a single sector. This overlap reinforces the argument that cost escalation is driven by shared institutional and budgeting dynamics rather than sector-specific technical factors alone.

Figure 3. Distribution of cost overruns in health and education infrastructure projects

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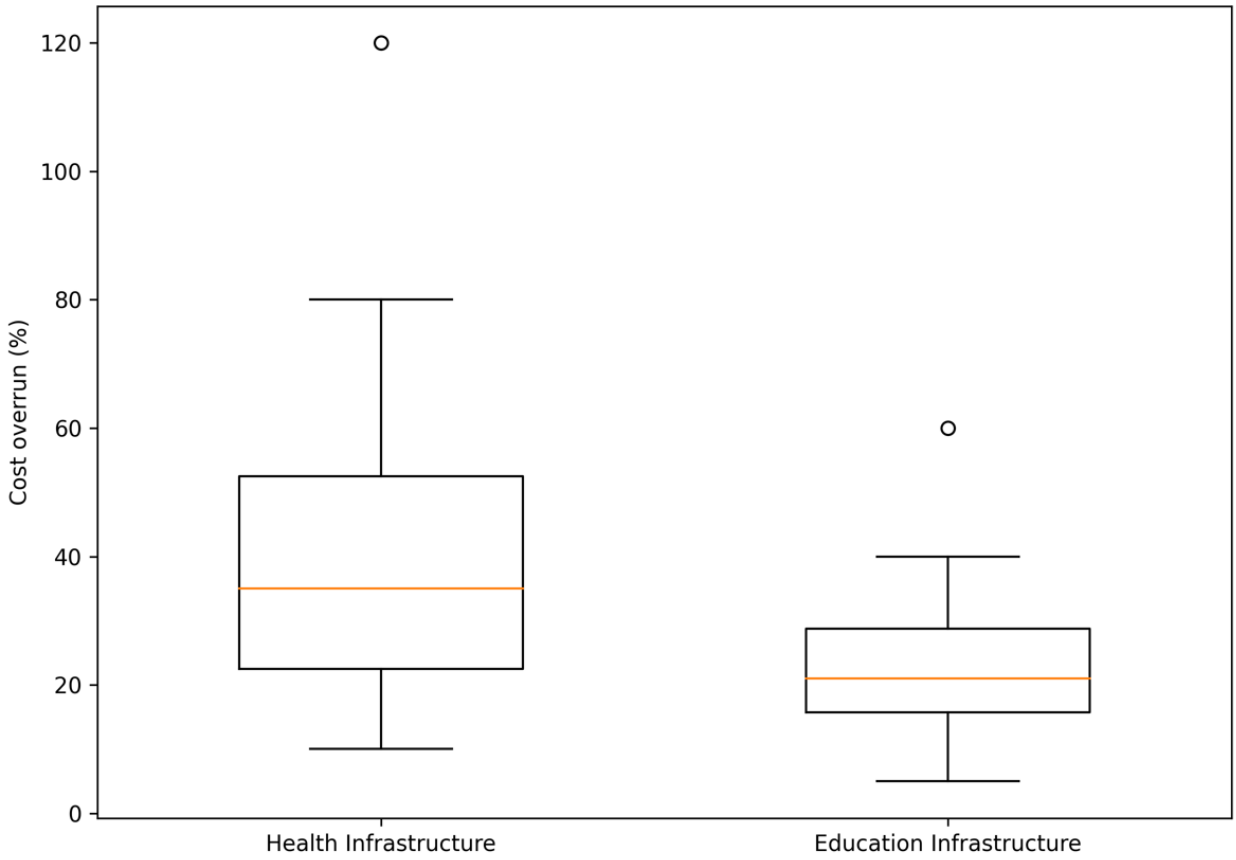

Comparative bar chart or box plot showing the distribution of cost overruns (%) across health and education infrastructure projects.

The integrated evidence presented in this highlights a fundamental paradox at the heart of public health and education infrastructure investment. Fiscal constraints and budgetary rigidity encourage conservative budgeting and politically acceptable cost estimates, yet these same constraints systematically suppress recognition of risk and uncertainty. Cost overruns thus emerge as predictable outcomes of institutionalized practices rather than unexpected deviations.

By embedding project-level cost performance within global budget allocation patterns and fiscal dynamics, this establishes the empirical foundation for the analytical examination of drivers. The persistence of cost overruns across income groups and sectors suggests that meaningful improvement will require reforms targeting incentive structures and institutional design, rather than relying solely on technical enhancements to estimation methods.

The global evidence presented cost overruns in public health and education infrastructure are systematic, persistent, and widespread across income groups. Empirical regularities to analytically examine the underlying drivers that generate these outcomes. Rather than treating cost estimation inaccuracies and budgeting failures as isolated technical shortcomings, the analysis conceptualizes them as the product of interacting fiscal, behavioral, institutional, and project-specific mechanisms. This integrated perspective helps explain why cost overruns persist despite repeated reform efforts and increasing technical sophistication in project appraisal.

At the most fundamental level, cost estimation and budgeting failures are rooted in the political economy of public finance. Governments operate under binding fiscal constraints defined by revenue capacity, debt sustainability rules, and macroeconomic stability objectives. Within these constraints, capital investment in health and education infrastructure must compete with recurrent expenditures that are politically difficult to compress, such as wages, pensions, and social transfers.

The capital budgets for health and education infrastructure are typically small, rigid, and volatile.

This structural context incentivizes project proponents to frame cost estimates in ways that maximize the likelihood of approval within predetermined budget envelopes. Rather than serving as neutral forecasts of expected expenditure, cost estimates become strategic signals of affordability. This dynamic explains why underestimation is most pronounced at early project stages, when political and fiscal pressures are strongest and uncertainty is greatest.

In public health and education infrastructure, these pressures are intensified by the moral and political imperative to expand service access. Hospitals and schools are perceived as essential public goods, making project postponement or rejection politically costly. As a result, decision-makers often tolerate optimistic estimates as the price of advancing socially desirable projects, implicitly shifting risk to the implementation phase.

Budget rigidity constitutes a second critical driver of estimation and budgeting failure. Medium-term expenditure frameworks and annual budget cycles impose temporal structures that are poorly aligned with the lifecycle of infrastructure projects. While health and education projects typically unfold over many years, budgets are approved within short-term horizons that discourage explicit recognition of long-term risks.

This temporal misalignment encourages systematic discounting of future uncertainties. Inflation, regulatory changes, technological evolution, and demand volatility are frequently treated as external shocks rather than as predictable features of complex projects. In health infrastructure, the delayed specification of medical equipment and digital systems illustrates this problem clearly. Equipment costs are often excluded or under-specified in early budgets, only to emerge later as major drivers of cost escalation. In education infrastructure, similar dynamics arise from demographic forecasting errors and unanticipated site development challenges.

The result is a budgeting process that appears disciplined ex ante but proves fragile ex post. Cost overruns are thus not failures of control but manifestations of risks that were implicitly excluded from the budgeting framework.

Behavioral explanations, particularly optimism bias, provide important insight into why planners systematically underestimate costs. However, the persistence of underestimation over time suggests that cognitive bias alone cannot account for observed outcomes. If optimism bias were purely individual, repeated forecasting failures would generate learning effects and gradual improvement. The absence of such improvement indicates that organizational and institutional contexts inhibit learning.

Public sector project organizations often lack mechanisms for systematic feedback from completed projects to future estimation practices. Cost overruns are rarely traced back to initial assumptions, and professional incentives rarely reward estimation accuracy. Instead, compliance with procedural requirements and timely project approval are emphasized. This organizational environment normalizes optimistic forecasting and discourages conservative estimation.

In health and education infrastructure, professional norms further complicate learning. Clinical and educational stakeholders prioritize functional adequacy and service quality, often viewing financial constraints as secondary considerations. This orientation can lead to systematic underestimation of costs associated with regulatory compliance, quality standards, and technological integration, which are treated as unavoidable additions rather than integral components of project scope.

While optimism bias explains unintentional underestimation, strategic misrepresentation accounts for deliberate distortion of cost estimates in response to incentive structures. Where project approval is rewarded and delivery performance is weakly sanctioned, actors face rational incentives to understate costs and downplay risk.

Projects compete for limited capital funds within rigid budgets, creating incentives to present lower estimates than rival proposals. Once approved, projects acquire political momentum, making cancellation or radical redesign unlikely even when costs escalate. This dynamic produces a form of institutional lock-in, whereby early estimation errors are absorbed rather than corrected.

In public health and education infrastructure, strategic misrepresentation is reinforced by political

visibility. Announcements of new hospitals or schools yield immediate reputational benefits, while cost overruns materialize gradually and are often attributed to external shocks. This temporal asymmetry weakens accountability and perpetuates estimation bias across electoral cycles.

Institutional quality moderates but does not eliminate estimation and budgeting failures. Strong governance systems introduce oversight mechanisms that reduce extreme overruns, yet underestimation persists even in high-capacity contexts. This suggests that governance reforms focused solely on procedural compliance are insufficient.

Procurement systems play a crucial role in translating estimation errors into cost escalation. Weak contractor selection, inappropriate risk allocation, and inadequate contract management amplify the consequences of underestimated costs. Health infrastructure projects are particularly vulnerable due to reliance on specialized suppliers and integrated technologies, while education projects face coordination challenges arising from dispersed sites and multiple implementing agencies.

Capacity constraints further exacerbate these challenges. Shortages of skilled estimators, engineers, and project managers limit the ability of public agencies to model risk effectively and manage complex delivery environments. These constraints are most visible in low- and middle-income countries but are also evident in specialized domains such as hospital planning in advanced economies.

Project complexity represents an endogenous source of uncertainty that is frequently underestimated. Health infrastructure projects integrate architectural design, mechanical and electrical systems, medical technologies, and regulatory requirements, creating interdependencies that are difficult to forecast accurately. Education infrastructure projects, while generally less technologically complex, often involve scale, dispersion, and site-specific variability that complicate standardization.

Complexity interacts with institutional and behavioral drivers by increasing ambiguity at early stages. This ambiguity makes it easier to defer cost recognition and justify later revisions as unforeseeable. In this sense, complexity does not merely increase risk; it creates conditions under which optimistic estimation and budgetary suppression become institutionally acceptable.

The analysis demonstrates that cost estimation and budgeting failures in public health and education infrastructure are best understood as emergent outcomes of interacting mechanisms rather than as isolated deficiencies. Fiscal constraints create pressure for affordability signaling; budget rigidity suppresses risk recognition; behavioral and strategic incentives normalize optimism; and institutional weaknesses limit corrective capacity. These drivers reinforce one another, producing a stable equilibrium of underestimation and subsequent cost escalation.

Table 3. Analytical classification of drivers of cost estimation and budgeting failures

Driver Category	Core Mechanism	Effect on Cost Estimation	Effect on Budgeting	Key Implications
Fiscal constraints	Limited fiscal space	Downward-biased estimates	Underfunded budgets	Approval-driven estimation
Budget rigidity	Fixed expenditure ceilings	Risk exclusion	Inflexible budgets	Cost escalation ex post
Behavioral factors	Optimism bias	Overconfidence	Weak learning	Persistent underestimation
Strategic incentives	Political rewards	Deliberate understatement	Risk shifting	Institutional lock-in
Governance capacity	Weak oversight	Poor validation	Ineffective correction	Variance in outcomes
Project complexity	Endogenous uncertainty	Scope under-specification	Contingency suppression	Late-stage escalation

The analysis presented in the preceding sections demonstrates that cost estimation and budgeting challenges in public health and education infrastructure projects are deeply rooted in the institutional architecture of public investment systems rather than in isolated technical shortcomings. Across income groups and governance contexts, systematic underestimation and subsequent cost overruns emerge as predictable outcomes of how projects are framed, approved, and financed. These finding challenges dominant project management narratives that continue to treat cost overruns primarily as failures of forecasting accuracy or managerial competence.

A key insight from this study is that cost overruns should be understood as institutional outcomes rather than project anomalies. The persistence of underestimation over time, even in countries with advanced planning systems, suggests that the problem lies upstream of project delivery. Budgeting frameworks that prioritize short-term affordability and political feasibility create strong incentives to suppress uncertainty and present optimistic cost profiles. In this environment, cost estimates function less as forecasts of expected expenditure and more as instruments for navigating fiscal and political constraints. Once projects are approved, the realization of previously excluded risks manifests as cost escalation, scope adjustments, or quality compromises.

The findings also help reconcile behavioral and strategic explanations of estimation bias, which are often treated as competing perspectives in the literature. Optimism bias plays an important role in the early conceptualization of projects, particularly in complex and socially salient sectors such as health and education. Planners and decision-makers tend to focus on best-case scenarios, underestimating the likelihood and magnitude of adverse outcomes. However, the persistence of underestimation over multiple project cycles indicates that cognitive bias alone is insufficient as an explanation. Strategic incentives embedded in budgeting and approval processes reinforce optimistic forecasting by rewarding project initiation while weakly sanctioning delivery failures. Over time, these dynamics produce an institutional equilibrium in which optimism becomes normalized and learning is systematically constrained.

The sectoral comparison between health and education infrastructure further strengthens this interpretation. While health projects exhibit higher average cost overruns and greater dispersion due to their technical complexity and regulatory intensity, education projects display similar patterns of systematic underestimation, albeit at lower magnitudes. The substantial overlap in cost overrun distributions across sectors suggests that sector-specific technical factors cannot fully account for observed outcomes. Instead, shared fiscal constraints, rigid capital budgeting practices, and political salience shape estimation behavior in both domains. This convergence highlights the importance of addressing common institutional drivers while remaining attentive to sector-specific risk profiles.

From a theoretical perspective, the study contributes to public investment management and infrastructure governance scholarship by explicitly linking cost estimation practices to budgeting systems. Much of the existing literature focuses on improving project appraisal techniques, procurement processes, or contract management. While these interventions are necessary, the findings suggest that they are unlikely to deliver sustained improvements in cost performance unless accompanied by reforms that address the incentive structures governing project approval and budget allocation. In particular, the treatment of uncertainty and contingency within public budgets emerges as a critical weakness. Current norms often frame contingency provisions as inefficiencies rather than as prudent risk management tools, discouraging realistic estimation and transferring risk to later stages of project delivery.

For practitioners, the discussion underscores that improving cost estimation accuracy requires institutional alignment across the project lifecycle. Independent reviews, reference-class forecasting, and staged approvals can help counteract optimism bias and strategic misrepresentation, but their effectiveness depends on political support and enforcement capacity. In the context of health and education infrastructure, closer integration between finance ministries and sector agencies is especially important, given the long-term operational and service delivery implications of capital investment decisions.

The findings of this study have important implications for the design of public investment and budgeting reforms aimed at improving cost performance in health and education infrastructure projects. Rather than focusing narrowly on technical estimation methods, reform efforts should prioritize institutional and incentive-based changes that reshape how uncertainty, risk, and accountability are treated within public budgeting systems.

One critical implication concerns the treatment of risk and contingency in capital budgets. Public budgeting frameworks should explicitly recognize uncertainty as an inherent feature of complex infrastructure projects rather than as a deviation from ideal planning. This requires normalizing the inclusion of contingency allowances and risk-adjusted cost estimates at the approval stage, supported by transparent justification rather than penalized as inefficiency. Where fiscal rules constrain flexibility, mechanisms such as centrally managed contingency reserves or staged funding commitments can help balance fiscal discipline with realism.

A second implication relates to project approval and accountability structures. Separating the functions of project advocacy, appraisal, and approval can reduce incentives for strategic misrepresentation. Independent review bodies with the authority to challenge optimistic assumptions and require reference-class forecasting can strengthen estimation credibility. Importantly, accountability mechanisms should extend beyond approval to encompass delivery outcomes, linking estimation accuracy to professional and organizational performance assessment.

Procurement and contract design also play a crucial role in translating estimation realism into delivery performance. Risk allocation should reflect the parties best positioned to manage specific uncertainties, rather than transferring excessive risk to contractors in ways that encourage strategic pricing and later renegotiation. In health infrastructure projects, early integration of equipment planning and digital systems into cost estimates can reduce late-stage escalation, while in education projects, standardized designs and phased implementation can mitigate coordination risks.

Finally, capacity development remains essential, particularly in low- and middle-income countries. Strengthening technical expertise in cost estimation, project management, and contract administration can enhance the effectiveness of institutional reforms. However, capacity-building efforts should be embedded within broader governance reforms to ensure that improved technical skills are not undermined by misaligned incentives.

The findings of this study carry important implications for public investment policy, budgeting systems, and infrastructure governance in the health and education sectors. The persistence of cost estimation errors and budget overruns across countries and income groups suggests that incremental technical improvements alone are unlikely to deliver meaningful change. Instead, reforms must address the institutional incentives and structural constraints that shape how cost information is generated, evaluated, and acted upon.

A first implication concerns the design of public budgeting frameworks. Current practices prioritize short-term fiscal control and compliance with expenditure ceilings, often at the expense of realism. Introducing explicit mechanisms to accommodate uncertainty—such as mandatory risk-adjusted cost estimates and transparent contingency provisions—would help align approved budgets more closely with expected project costs. Importantly, such provisions should be normalized within budgeting systems rather than treated as indicators of inefficiency or poor planning. Without this shift in norms, cost risks will continue to be suppressed at appraisal stages and re-emerge during implementation.

A second implication relates to the institutional separation between project appraisal and budget approval. In many systems, sectoral ministries are responsible for preparing cost estimates, while finance ministries focus primarily on aggregate affordability. This division creates misaligned incentives, as project proponents face pressure to minimize estimates to secure approval, while finance authorities lack detailed sectoral insight to challenge assumptions. Strengthening independent review functions—either within finance ministries or through external appraisal units—can help counterbalance these incentives, particularly for large health and education infrastructure projects with high complexity and long delivery horizons.

Third, the findings underscore the importance of aligning accountability mechanisms with estimation accuracy rather than procedural compliance. In many public organizations, professional rewards are linked to successful project approval and budget absorption, while limited attention is paid to forecast accuracy or lifecycle cost performance. Introducing systematic post-project reviews that explicitly compare initial estimates with actual outcomes, and feeding these results back into future appraisal processes, would support organizational learning. Over time, such feedback loops could help shift professional norms away from optimism and toward evidence-based forecasting.

Procurement and contract design also emerge as critical levers for reform. Poorly allocated risks and weak contract management amplify the consequences of underestimation, particularly in health infrastructure projects that rely on specialized technologies and integrated systems. Greater use of procurement strategies that encourage early contractor involvement and collaborative risk management may improve cost realism, provided they are embedded within robust governance frameworks. In education infrastructure, where projects are often delivered at scale across multiple sites, standardized designs and centralized procurement platforms can reduce uncertainty and improve cost control.

Finally, the analysis highlights the need for stronger integration between capital investment planning and long-term service delivery strategies. Health and education infrastructure projects generate substantial recurrent costs over their lifecycle, yet these costs are often weakly connected to capital budgeting decisions. Closer alignment between infrastructure planning, workforce strategies, and operational budgeting would improve both estimation accuracy and fiscal sustainability. This integration is particularly important in contexts facing demographic change, technological transformation, and increasing demand for resilient public services.

The findings of this study carry important implications for policymakers, public financial management authorities, and infrastructure practitioners seeking to improve cost performance in public health and education projects. The persistence of cost underestimation and budget escalation across income groups indicates that incremental technical improvements in cost estimation methods are unlikely to deliver meaningful change unless they are embedded within broader institutional and incentive reforms.

A first implication concerns the design of budgeting frameworks for capital investment. Current practices in many countries prioritize short-term fiscal control and affordability signaling over realism and risk recognition. While fiscal discipline is essential, excessive rigidity in capital budgets suppresses explicit acknowledgment of uncertainty and encourages optimistic estimation. Governments should therefore move toward budgeting frameworks that distinguish more clearly between baseline project costs and risk-adjusted contingencies. Treating contingencies as legitimate components of prudent financial management, rather than as inefficiencies, would reduce the need for ex post budget reallocations and emergency funding.

A second implication relates to project appraisal and approval processes. The analysis suggests that early-stage project approval is a critical juncture at which estimation bias becomes institutionalized. Introducing staged approval mechanisms, in which projects receive incremental authorization as design maturity and information quality improve, can help mitigate this problem. Such approaches allow initial decisions to be revisited as uncertainty is reduced, limiting the lock-in effects associated with early optimistic estimates. Reference-class forecasting and independent cost reviews are particularly valuable at these stages, provided they are insulated from political pressure and have a clear mandate to challenge unrealistic assumptions.

Governance and accountability mechanisms also require attention. In many public systems, responsibility for cost estimation, budget approval, and project delivery is fragmented across institutions, weakening accountability for estimation accuracy. Strengthening horizontal coordination between finance ministries, sectoral agencies, and implementing bodies can help align incentives across the project lifecycle. In health and education infrastructure, closer integration between capital planning and service delivery objectives is especially important, given the long-term operational and

fiscal implications of infrastructure decisions.

Capacity development remains a necessary, though insufficient, condition for improvement. Investments in professional training, standardized estimation practices, and data systems can enhance forecasting capability, particularly in low- and middle-income countries. However, without parallel reforms to incentive structures, improved capacity may simply enable more sophisticated forms of strategic misrepresentation. Capacity-building efforts should therefore be accompanied by institutional arrangements that reward estimation accuracy and penalize systematic underestimation.

Finally, the findings underscore the importance of transparency and learning. Systematic ex post evaluation of completed projects, with explicit comparison between initial estimates and actual outcomes, can support organizational learning and improve future decision-making.

This study set out to evaluate cost estimation and budgeting challenges in public health and education infrastructure projects through a global and institutional lens. Drawing on international fiscal data, sector-specific evidence, and interdisciplinary theoretical perspectives, the analysis demonstrates that persistent cost overruns are not isolated project-level failures but structural outcomes embedded within public investment and budgeting systems. Across income groups and governance contexts, systematic underestimation emerges as a predictable consequence of fiscal constraints, budget rigidity, behavioral biases, and incentive misalignment.

The findings challenge the dominant narrative that attributes cost overruns primarily to technical deficiencies or weak project management capacity. While technical complexity and uncertainty are undeniably relevant—particularly in health infrastructure—the evidence shows that similar patterns of underestimation persist even in contexts with advanced planning systems and professional expertise. This persistence underscores the central role of institutional design and political economy dynamics in shaping estimation behavior. Cost estimates frequently function as instruments of affordability and political feasibility rather than as neutral forecasts of expected expenditure.

By explicitly linking cost estimation practices to public budgeting frameworks, the study advances infrastructure governance theory in several important ways. First, it reframes cost overruns as institutionalized outcomes of budgeting systems that prioritize short-term fiscal control over long-term realism. Second, it integrates behavioral explanations such as optimism bias with strategic misrepresentation, demonstrating how cognitive tendencies are reinforced by organizational incentives rather than corrected through learning. Third, it extends cost overrun research beyond its traditional focus on transport and energy megaprojects, highlighting the distinct yet structurally similar challenges faced in public health and education infrastructure.

From a policy perspective, the analysis suggests that meaningful improvement in cost performance will require reforms that go beyond technical enhancements to estimation methods. Strengthening institutional incentives for realism, improving feedback mechanisms from completed projects, and embedding risk-adjusted thinking within budgeting frameworks are critical steps. In particular, the treatment of contingency and uncertainty within public budgets warrants reconsideration, as current practices often suppress rather than manage risk. Greater coordination between finance ministries and sectoral agencies is also essential, especially in health and education sectors where capital investments have long-term operational and service delivery implications.

The study is not without limitations. As a synthesis-based analysis relying on secondary data and published evidence, it does not provide project-level causal testing. However, this approach is appropriate given the study's objective of explaining global and systemic patterns rather than evaluating individual projects. The conceptual framework developed here should be seen as a foundation for future empirical work rather than a definitive causal model.

Future research could build on this study in several directions. Quantitative testing of the proposed framework using large-scale project datasets would help assess the relative strength of identified drivers. Comparative case studies could further illuminate how institutional arrangements mediate estimation and budgeting outcomes in different governance contexts. Additionally, emerging challenges—such as climate resilience requirements, digital health infrastructure, and demographic

shifts—are likely to introduce new sources of uncertainty that interact with existing budgeting constraints and deserve closer examination.

In conclusion, improving cost estimation and budgeting performance in public health and education infrastructure is less a matter of refining forecasting techniques than of addressing the institutional environments in which those techniques are applied. Recognizing cost overruns as systemic and predictable outcomes is a necessary first step toward designing public investment systems that deliver infrastructure more reliably, efficiently, and equitably.

In social infrastructure sectors that are politically sensitive, transparency can play a critical role in counterbalancing short-term incentives for optimism.

This study has examined cost estimation and budgeting challenges in public health and education infrastructure projects through a global, cross-sectoral lens. Drawing on international fiscal data, empirical evidence on cost overruns, and interdisciplinary theory, the analysis demonstrates that persistent underestimation and budgetary deviation are not accidental or episodic failures. Rather, they are systemic outcomes of how public investment decisions are structured, incentivized, and governed.

The evidence synthesized in this paper shows that cost overruns in health and education infrastructure are widespread across income groups and institutional contexts. Although the magnitude of overruns varies—often higher in technically complex health infrastructure than in education projects—the direction of bias is consistently upward. This pattern confirms that estimation inaccuracy is embedded in institutional practice rather than driven solely by technical uncertainty or local capacity constraints. Fiscal ceilings, rigid budgeting frameworks, and political imperatives to demonstrate affordability combine to suppress realistic recognition of risk at the appraisal stage, effectively transferring uncertainty to later phases of project implementation.

By integrating behavioral, institutional, and political economy perspectives, the study advances the literature beyond narrow explanations focused on forecasting techniques or project management deficiencies. Optimism bias and strategic misrepresentation are shown to coexist and reinforce one another within budgeting systems that reward project approval while weakly sanctioning delivery failure. These dynamics are further amplified by limited organizational learning, fragmented accountability, and procurement systems that inadequately allocate risk.

A key contribution of this research lies in explicitly linking cost estimation practices to public budgeting frameworks. Cost estimates are not neutral technical inputs into budgeting decisions; they are shaped by the fiscal architecture and incentive structures within which they are produced. As a result, reforms that focus exclusively on improving estimation methodologies are unlikely to yield sustained improvement unless they are accompanied by changes in institutional design, incentive alignment, and governance arrangements.

The comparative focus on public health and education infrastructure underscores both shared challenges and sector-specific nuances. While health projects face greater technological and regulatory complexity, and education projects often encounter coordination and scale-related risks, both sectors operate within similar fiscal and political constraints. This convergence suggests that reforms targeting budgeting flexibility, independent review, and risk-informed decision-making can generate cross-sectoral benefits, even as technical solutions must remain context-sensitive.

From a policy perspective, the findings highlight the importance of moving beyond symbolic commitments to cost control toward institutional reforms that embed realism into public investment decision-making. This includes legitimizing contingency provisions, strengthening independent appraisal and review mechanisms, integrating capital budgeting with long-term service delivery planning, and enhancing feedback loops from completed projects to future estimates. Such reforms are essential not only for improving fiscal discipline but also for safeguarding the social returns of public investment in health and education infrastructure.

Future research should empirically test the conceptual framework developed in this study using project-level datasets, comparative case studies, and mixed-method approaches. Further

disaggregation within health and education sectors, as well as examination of emerging pressures such as climate adaptation and digital integration, would deepen understanding of how cost estimation and budgeting challenges are evolving. Addressing these issues remains critical for ensuring that public infrastructure investment delivers sustainable value and supports long-term development objectives.

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