

A Scalable Capital Expenditure Management Framework

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Abstract

This paper presents a comprehensive and scalable framework for capital expenditure (CapEx) management, designed to be applicable across various industries for organizations engaged in complex capital projects or operating in capital-intensive sectors. The framework integrates strategic alignment, phase-gated governance, standardized evaluation methodologies, and digital automation into a unified CapEx lifecycle, covering the entire process from idea intake to post-implementation review. Organizations that adopt this model can improve capital allocation efficiency, enhance return on invested capital (ROIC), reduce financial and operational risks, and strengthen transparency in investment decision-making by addressing governance and evaluation gaps in capital projects. The scientific significance arises from the integration of diverse capital governance disciplines, financial modeling, risk analytics, ESG tracking, and digital systems into a unified and operationally executable model. Importantly, this framework will deliver a new multi-model governance architecture, comprising standard, Front-End Loading (FEL), and milestone-based models, adaptable to both infrastructure-heavy industries and innovation-driven environments. This article applies those principles in a structured, technology-enabled model, providing a practical implementation roadmap aligned with those performance benchmarks. Thus, the proposed framework addresses current issues in capital project governance, including a lack of strategic alignment, fragmented oversight, unclear evaluation standards, and poor digital traceability, and provides a scalable foundation for enterprise-wide investment supervision and capital productivity enhancement.

Keywords

Capital Investment, CapEx Governance, Phase-Gated Governance, Financial Model, ESG, Strategic Alignment, Capital Project Prioritization, Risk Management, ERP Integration

1. Introduction

Capital investment is a major driver of long-term growth and a source for sustaining competitive advantage. The U.S. Census Bureau reported that in 2022, non-farm entities in the United States invested over \$2.19 trillion in CapEx (US Census Bureau, 2024). The scale of capital investment highlights the strategic importance of effective investment management for organizations across various industries.

Challenges in CapEx management persist across industries. Many organizations lack sufficient expertise in capital project governance. The absence of an integrated approach, combined with limited enterprise-wide systems, unclear governance structures, and inadequate performance tracking, continues to result in execution delays, budget overruns, and underperformance in ROIC.

Organizations that adopt an integrated approach across the full project life cycle, the capital projects portfolio oversight, and the necessary foundational enablers can reduce project costs and timelines by up to 30% while increasing ROIC by 2 to 4 percentage points (Brinded et al., 2022).

This paper proposes a comprehensive and adaptable CapEx management model designed to address these gaps. The model combines strategic prioritization with phase-gated oversight, standardizes financial modeling, and integrates digital tools throughout the entire project lifecycle, from idea inception to post-implementation assessment. This model helps organizations mitigate financial risk, make informed decisions, and create long-term value by implementing greater organization, clarity, and strategic alignment into CapEx management.

2. Materials and Methodology

The study materials and methodology are based on a comprehensive review of both theoretical and empirical sources, as well as a comparison of current practices in managing capital expenditure. The primary data consisted of statistical information available from the U.S. Census Bureau on total capital expenditures in the non-farm sector for the year 2022 (US Census Bureau, 2024), coupled with the McKinsey industry report discovery on the improvement of CapEx-project performance (Brinded et al., 2022). The theoretical base was derived from work in phase-gate management (Bakke & Johansen, 2025), writing on the digital design of ERP systems (Nendrambaka, 2024), portfolio management of R&D projects (Hsuan, 2000), as well as a comparison of IFRS and US GAAP rules for capitalizing development costs (Zielhoff & Wojtanek, 2025).

The framework was derived from professional implementation experience and formalized through a three-stage review of industry methodologies and academic literature, ensuring alignment between academic evidence and real-world applicability. In the first stage, review of internal governance policies, process documentation, and implementation practices to identify procedural norms and execution challenges. In the second stage, grey literature from leading consultancies (McKinsey, Deloitte, Bain) and sector-specific white papers was collected and thematically coded to extract recurring practices and governance patterns. In the third stage, a

targeted academic literature review was performed using databases such as Scopus, Web of Science, and Google Scholar, with search terms including “CapEx governance,” “phase-gate management,” and “ERP integration.” A significant number of peer-reviewed sources were screened for methodological rigor and relevance. Insights from all three stages were synthesized to define the core components of the proposed framework.

The study combines these methods: a thorough look at books, articles and industry practices on strategic alignment, portfolio optimization, and digital automation; comparing three phase-gate management models, standard, FEL, and milestone-based, on how well they control depth, detail in ways to estimate costs or time needed for a project, and what kind of data they need; and making a list of the best ways to add financial models, risk check tools, and ESG monitoring into a single system for managing.

To evaluate the flexibility and scalability of the proposed framework, a review of industry practices was conducted on implementation examples in infrastructure-oriented and innovation-driven organizations. The employed methods included content analysis of project documentation, comparative examination of stage artifacts (strategic briefs, financial models, risk registers), and verification of linkages between digital Gate-approval portals and ERP systems.

In conclusion, the model’s development was accompanied by the iterative construction of an implementation roadmap, including clearly defined governance roles, Delegation of Authority regulations, and recommendations for designing analytical dashboards for post-project review. This approach ensures reproducibility of results and enables rapid adaptation of the methodology to the specific characteristics of different industries and organizational structures.

3. Results and Discussion

3.1. Categorization of CapEx

Capital investment categorization is foundational to effective CapEx governance. It ensures alignment with the enterprise strategy, accurate evaluation of return metrics, clear prioritization of funding, and consistent accounting treatment in accordance with corporate finance policies and applicable accounting standards (e.g., IFRS, US GAAP). Core CapEx categories include growth and efficiency, maintenance, and compliance investments.

Growth and efficiency CapEx comprises strategic projects that expand the organization’s revenue, product offerings, geographic reach, or operational efficiency. These projects often require substantial upfront investments to generate sustainable financial returns by increasing productive capacity, launching new products, entering new markets, or scaling operations.

A subset of these investments includes R&D initiatives, which typically focus on innovation projects such as proprietary AI models, digital platforms, or advanced prototyping infrastructure. These projects are typically characterized by higher uncertainty and longer time horizons. Under IFRS, certain development-

phase costs may be capitalized if they meet technical and economic feasibility criteria, while under US GAAP, R&D is generally expensed unless specific exceptions apply. Where capitalization is appropriate, such projects can be tracked as a distinct sub-class within growth and efficiency CapEx to ensure visibility and governance in innovation-focused portfolios.

Maintenance CapEx refers to expenditures required to preserve the function and reliability of existing assets. While routine repairs and servicing are typically treated as operating expenses, substantial replacements or upgrades that restore or extend the life of fixed assets qualify as capital investments.

Compliance CapEx comprises mandatory investments initiated by a regulatory, environmental, or safety imperative. In the main, projects under this category are not driven by return on investment; they must be undertaken to maintain licensing, avoid penalties, mitigate risk, and ensure business continuity. Compliance-related CapEx is not inherently related to ESG; instead, there is often an intersection between compliance and sustainability objectives.

In addition to these core CapEx categories, the framework incorporates a set of strategic characteristics that help organizations classify and evaluate projects based on their digital focus and level of innovation, sustainability impact, and infrastructure scale.

Digital and Innovation projects typically constitute the integration of mature technologies, such as enterprise resource planning (ERP) systems, robotic process automation (RPA), and cloud platforms, into capital projects across sectors. These projects are generally included within growth and efficiency, maintenance, or compliance categories, rather than presented as a separate category. This is not the same as R&D initiatives, as these works involve implementing existing business solutions.

Efficiency and Sustainability (ESG) must be tagged in all CapEx categories to drive ESG performance reporting, as well as capital allocation transparency. Qualifying projects, such as energy optimization, emissions control, or climate adaptation infrastructure, can be capitalized if they meet asset recognition criteria. Depending on the organization's strategy or external disclosure mandates, ESG CapEx can also be reported as a distinct CapEx category.

Infrastructure CapEx comprises capital projects by large-scale physical assets: buildings, transportation systems, energy networks, utilities, and public service facilities. Investments often overlap with other main CapEx categories. For example, from the perspective of growth, a new manufacturing plant or transit terminal may be included; from the perspective of maintenance, upgrading tunnel ventilation systems or rehabilitating bridges may be included; and from the perspective of compliance, fire safety upgrades or seismic strengthening will most often be included. Infrastructure CapEx ought to be monitored across the portfolio to support lifecycle planning, strategic fund allocation, and benchmarking of capital efficiency.

In some instances, Infrastructure CapEx may be presented as a standalone CapEx category, particularly when the investment forms part of a public-private partnership or involves dedicated infrastructure financing vehicles; the project entails multi-asset, long-horizon investments requiring distinct governance and report-

ing (e.g., city-scale redevelopment, utility grid modernization); the organization follows regulatory or industry-specific disclosure requirements that mandate reporting of infrastructure spend separately (e.g., for sustainability-linked loans).

Sector-specific examples demonstrate the framework's adaptability and applicability across various industries, as shown in **Table 1**.

Table 1. Sector-specific CapEx examples demonstrating the framework's adaptability and applicability across various industries (compiled by the author).

Sector	Growth and Efficiency CapEx	Maintenance CapEx	Compliance CapEx
Energy & Utilities	Development of a solar farm or wind park (<i>ESG</i>)	Transformer refurbishment, turbine blade replacement	Emissions monitoring upgrades, grid protection compliance (<i>ESG</i>)
IT & Software	Launch of regional data center, enterprise cloud expansion (<i>Digital</i>)	Server replacement, uninterruptible power supply repair	SIEM system implementation (<i>Digital</i>)
Oil & Gas	LNG terminal expansion	Heat exchanger replacement	Methane detection systems, pipeline spill mitigation (<i>ESG</i>)
Real Estate	Commercial property development, new residential complex	Elevator replacement, HVAC system overhaul	Fire code upgrades, accessibility retrofits (<i>ESG</i>)
Consumer Goods/FMCG	Installation of high-speed production line, warehouse expansion	Refrigeration system replacement, bottling machine repair	HACCP and FSMA food safety compliance upgrades (<i>ESG</i>)
Healthcare	Expansion of hospital facility, specialized care unit (<i>ESG</i>)	MRI scanner replacement, air handling unit servicing	Infection control retrofits, HIPAA compliance upgrades (<i>ESG</i>)
Telecommunications	Fiber optic rollout, 5G infrastructure expansion (<i>Infrastructure, Digital, ESG</i>)	Antenna and signal amplifier servicing	Radio frequency safety compliance, lawful intercept protocols
Manufacturing	Robotics installation, 3D printing system setup (<i>Digital</i>)	CNC spindle replacement, hydraulic press repair	Dust and emissions control installations (<i>ESG</i>)
Public Sector/Government	Smart city infrastructure, school construction (<i>ESG, Infrastructure, Digital</i>)	HVAC retrofits in public buildings, roadway resurfacing (<i>Infrastructure</i>)	Accessibility enhancements, environmental compliance (<i>ESG</i>)

3.2. Capitalization Rules

CapEx refers to investments made to acquire, construct, or upgrade assets that are expected to generate economic benefits beyond the current financial reporting period. For expenditures to qualify as capitalizable, they must meet the recognition criteria defined by relevant accounting standards, such as the IFRS or the US GAAP.

The general conditions for capitalization require that the expenditure be directly attributable to preparing the asset for its intended operational use. Additionally, the associated future economic benefits must be both probable and capable of being reliably measured. In contrast, routine maintenance activities, general repairs, and overhead costs are excluded from capitalization and are instead clas-

sified as operating expenses (OpEx).

Finance and accounting teams typically assess these criteria at the early stages of the investment lifecycle, often at Gate 0 (concept initiation) or Gate 1 (preliminary investment case). Most organizations embed capitalization rules directly into their enterprise resource planning (ERP) systems, applying automated workflows and control logic that align with corporate accounting policies and internal governance frameworks (see Section 3.7: System Setup Structure). These configurations may include thresholds for asset recognition (e.g., a minimum project value of \$50,000) and category-specific validation steps to ensure compliance.

For more complex capital projects, cost component analysis is applied to distinguish between capitalizable and non-capitalizable items. For instance, in a cloud migration project, costs related to system configuration and software licensing are generally capitalized, while expenses associated with staff training, data migration, and change management are treated as operating expenditures.

These classifications are typically mapped within standardized IBC templates used for budgeting, forecasting, and investment appraisal. Proper cost attribution supports accurate depreciation schedules, capital funding analysis, and post-implementation performance reporting.

By embedding capitalization logic into digital planning and ERP systems, organizations strengthen audit readiness, reduce manual classification errors, and ensure consistency in financial reporting across units. A disciplined approach to cost categorization not only enhances financial control but also improves the efficiency of benchmarking, capital governance, and financial close processes.

3.3. Phase-Gated Governance Models

Capital project governance varies widely across industries due to differences in investment size, technical complexity, delivery risk, and strategic exposure. This framework introduces a practical, adaptable classification that enables organizations to align governance rigor with project characteristics. Drawing from broad industry practices and comparative analysis, it defines three primary governance models: standard phase-gated governance, phase-gated governance with FEL discipline, and milestone-based phase-gated governance, each tailored to different sectors and project types (**Table 2**).

While these models differ in governance depth and delivery rhythm, all capital projects advance through a standardized sequence of Gate reviews. Each Gate functions as a formal investment checkpoint, allowing progressive capital commitment based on growing confidence in scope, schedule, risk mitigation, and expected returns, as shown in **Table 3**.

Each Gate review is conducted via a centralized digital portal, where teams submit risk registers, financial models, assumption lists, and digital approvals. Integration with the ERP system ties Gate approvals directly to budget releases, audit logs, and automated workflows, ensuring transparency, traceability, and the option to terminate a project early if it fails to meet the criteria.

Table 2. Governance model summary: sector applications and use case characteristics (compiled by the author).

Governance Model	Typical Sectors/Projects	Use Case Characteristics
Standard Phase-Gated Governance	IT infrastructure, data centers, logistics facilities, facility expansions, internal upgrades	Moderately complex projects with well-defined scope and stable requirements; repeatable or modular investments; suitable where speed, standardization, and structured approvals are prioritized over deep front-end planning
FEL-Enhanced Phase-Gated Governance	Oil & gas, chemicals, power utilities, mining, large-scale infrastructure, complex real estate developments	Capital-intensive and technically complex projects with high execution risk require detailed front-end planning (e.g., feasibility, permitting, constructability); often subject to regulatory scrutiny and stakeholder oversight
Milestone-Based Phase-Gated Governance	Digital platforms (e.g., SaaS), AI/ML, gaming, innovation-driven R&D, internal-use software	High-uncertainty environments with evolving requirements; supports iterative planning, milestone-linked funding, and adaptive decision-making; suitable for capitalized innovation programs using agile oversight frameworks

Table 3. Stage-gate process: focus areas, key deliverables, and decision criteria across each gate (compiled by the author).

Gate	Focus Area	Key Deliverables	Decision Criteria
Pre-Gate	Idea Screening	<ul style="list-style-type: none"> - Idea submission/intake - Market opportunity identification - Initial strategic fit assessment 	<ul style="list-style-type: none"> - Idea aligns with business priorities - Worth advancing to structured evaluation
Gate 0	Concept and Strategic Alignment	<ul style="list-style-type: none"> - Strategic brief (rationale and business need) - Initial concept brief - Alignment with enterprise strategy and KPIs - Executive sponsor identified - High-level budget estimate (no detailed cost estimates yet) 	<ul style="list-style-type: none"> - Alignment with enterprise strategy - Justifies advancement to Gate 1 evaluation - No major financial commitment
Gate 1	Preliminary IBC and Risk	<ul style="list-style-type: none"> - High-level technical scope and baseline assumptions - Preliminary CapEx estimate ($\pm 30\%$ - 50%) - ROI, NPV, IRR model - Top risks identified - ESG relevance flagged - Value drivers identified 	<ul style="list-style-type: none"> - Meets financial and strategic thresholds - Risks are scoped - Investment logic validated - The project may be halted or re-scoped if thresholds are not met
Gate 2	Budget-Ready Scope & Validation	<ul style="list-style-type: none"> - Refined CapEx estimate ($\pm 15\%$ - 20%) - Vendor quotes and sourcing plans - Integrated schedule and execution plan - Final financial model (DCF, sensitivity, Monte Carlo) - ESG or carbon impact assessment 	<ul style="list-style-type: none"> - Financial viability confirmed - Scope and execution plan validated - Ready for full budget release - Reviewed by the capital governance committee or equivalent
Gate 3	Execution Readiness	<ul style="list-style-type: none"> - Final contract package - QA/QC and delivery strategy - Resource plan and KPI baseline - ERP codes and budget control accounts issued - Procurement planning finalized 	<ul style="list-style-type: none"> - Full execution readiness achieved - Final budget approval complete - Risk mitigations finalized

At Pre-Gate, teams move from a basic intake form to framed opportunity assessments; at Gate 0 they supplement strategic briefs with preliminary feasibility work and ESG screening; at Gate 1 they expand from $\pm 30\%$ - 50% estimates to initial engineering scopes, preliminary CapEx estimates and first-cut execution strategies; at Gate 2 they build on refined CapEx estimates ($\pm 15\%$ - 20%) with full feasibility studies, constructability reviews and Monte Carlo simulations; and at Gate 3 they progress from final contract packages and KPI baselines to full QA/QC readiness, contract award strategies and regulatory clearances. Typical approvers evolve from strategy leads and project sponsors at early stages to Executive Leadership Teams, CEOs, or Boards at final approval.

To operationalize ESG integration within project evaluation, each proposal is expected to undergo a structured ESG assessment guided by standardized frameworks such as GRI and SASB. At Gate 1, teams prepare an ESG Impact Profile outlining environmental, social, and governance considerations relevant to the project. These may include metrics such as anticipated carbon reduction, stakeholder engagement strategies, or alignment with governance standards. ESG components are incorporated into the overall investment scorecard alongside financial and strategic factors, ensuring a balanced evaluation. Projects with material ESG risks are required to present mitigation measures or enhancement plans as part of their investment case. At Gate 2, designated sustainability or risk officers may conduct a validation review of ESG data and assumptions to confirm alignment with corporate sustainability goals. By embedding ESG assessment, risk mitigation, and verification into the phase-gate process, the framework treats sustainability as an integral factor in capital investment governance.

The standard phase-gated model is well-suited for relatively low CapEx undertakings such as modular data center expansions, warehouse builds, or internal IT upgrades, as well as for speed-to-market projects where waiting for full design maturity would delay benefits.

In contrast, capital-intensive, highly engineered sectors (for example, oil and gas, chemicals, large-scale utilities, or mega-real estate developments) incorporate FEL discipline. FEL intensifies Gates 0 - 2 with rigorous early-stage planning deliverables, detailed technical scopes, refined CapEx estimates, preliminary feasibility analyses, and early ESG screens to improve cost accuracy, reduce execution risk, and support regulatory readiness (Bakke & Johansen, 2025).

For digital, R&D, or innovation-driven initiatives, such as SaaS, AI/ML, or gaming, where technology, market fit, and requirements evolve rapidly, milestone-based phase-gated governance combines formal Gates at major funding points with agile milestone reviews. Light-touch milestone documentation (for example, sprint retrospectives and recalculated business cases), recurring internal checkpoints, and stage-gated funding tied to milestone outcomes allow iterative revalidation of strategy, risk, and financial assumptions. A pre-Gate stage filters out low-value or misaligned ideas before significant resources are committed. At the same time, major capital decisions still require full Gate reviews as project defini-

tion and confidence grow. This approach supports early termination or redirection of low-potential efforts, dynamic capital reallocation based on real-time progress, and transparent alignment of funding with product strategy.

This integrated model ensures that capital is committed only when execution confidence is high, risks are explicitly addressed, and value creation is validated. Ultimately, a structured phase-gated review process, whether standard, FEL-enhanced, or milestone-based, aligns funding decisions with growing confidence in scope, returns, and execution readiness. It ensures that capital is committed only when execution confidence is high, risks are explicitly addressed, and value creation is validated. By adjusting Gate requirements to project scale, complexity, and uncertainty, embedding reviews in digital workflows, and applying agile milestone governance where appropriate, organizations achieve better capital allocation, informed risk-taking, and clear, repeatable decision paths that suit diverse sectors without compromising speed.

3.4. Investment Business Case

An Investment Business Case (IBC) is a standardized, formal document or model used by organizations to evaluate and support transparent and accountable capital decisions. A well-structured IBC integrates strategic alignment, financial projections, risk and scenario analysis, ESG impact assessment, execution planning, scenario, and trade-off analysis. This section focuses on the core components: strategic alignment, financial modeling, and scenario-based risk management.

Strategic alignment ensures that investment proposals are assessed based on how well they align with and contribute to the enterprise's strategic objectives. At the earliest Gates, proposals are screened against enterprise priorities to ensure only initiatives with a clear strategic fit advance. A weighted scorecard combines metrics like ROI, NPV, IRR, and payback period with compliance and ESG relevance, creating a consistent framework for ranking and comparing projects. Progress is monitored through enterprise KPIs, such as EBITDA growth or emissions reduction, which are quantified in the IBC and validated at subsequent Gates. Meanwhile, executive oversight and quarterly portfolio reviews facilitate adjustments in timing or scope based on evolving strategic alignment.

The financial evaluation component of the IBC applies structured, risk-adjusted modeling to measure expected returns and protect against downside risk. Early indicators, such as Return on Investment, guide initial screening, but formal Gate reviews rely on discounted cash flow models using corporate discount rates to calculate Net Present Value (NPV) and Internal Rate of Return (IRR). A minimum IRR threshold, set according to industry benchmarks and risk appetite, ensures consistency in capital allocation. Discounted Payback Period analysis assesses liquidity risk, while the inclusion of Terminal Value captures long-term benefits of assets with ongoing cash generation potential. All financial models, accompanied by documented assumptions and methodologies, are submitted at Gate 1 and rigorously validated by Gate 2, then archived for post-implementation benchmark-

ing purposes.

Risk and scenario management are embedded throughout the investment lifecycle. By Gate 1, a comprehensive risk register categorizes and scores project-specific risks, including technical, market, financial, legal, and environmental risks, using a probability-impact matrix. For projects exceeding materiality thresholds (for example, \$5 million), teams conduct quantitative scenario modeling with Monte Carlo simulations or decision trees to assess volatility and identify break-even points. Tornado and sensitivity analyses visualize key drivers of NPV and IRR, focusing mitigation efforts on the most influential variables. High-exposure projects undergo escalation to risk oversight committees. At the same time, contingency reserves are calibrated according to modeled risk exposure rather than fixed percentages, ensuring proportional governance and efficient use of capital.

By combining strategic filters, rigorous financial metrics, and structured risk management within a unified IBC framework, organizations can commit capital with greater confidence in projected outcomes and increased transparency in decision-making processes. The hybrid approach ensures that funding decisions are made in alignment with the enterprise strategy, thereby supporting dynamic portfolio rebalancing and enforcing discipline without stifling innovation, which in turn improves project performance and value creation.

3.5. Corporate Governance and Approval Workflow

A strong CapEx governance setup ensures that investment choices are well-organized, clear, and aligned with the company's objectives and policies. Governance roles may vary depending on the organization's size, structure, and regulatory obligations. Each role must be clearly defined and aligned with the organization's Delegation of Authority matrix and corporate governance documents.

The project sponsor, usually a senior executive, is responsible for the business justification and strategic alignment of every suggestion; they also oversee the creation of the Investment Business Case. The project manager is responsible for planning and executing the work, ensuring that the scope, schedule, and budget are maintained. Finance representatives validate financial assumptions, cost categorization, and capital policy compliance, while risk managers maintain the project's risk register and support scenario modeling. Capital Review Committee evaluates each case based on financial returns, strategic alignment, and, where applicable, ESG considerations. High-value investments are directed to the executive leadership team or the CEO. At the same time, the Board of Directors retains ultimate authority over projects that exceed defined thresholds or those carrying significant strategic or reputational risk.

The Delegation of Authority matrix codifies approval rights based on project size and risk, ensuring decisions occur at the appropriate level, as illustrated in **Table 4**. These thresholds may be adjusted for industry sector, corporate structure, or geographic regulations to maintain proportional oversight.

Table 4. Approval thresholds by the total estimated CapEx value (compiled by the author).

Total Project CapEx	Approval Level
Up to \$1 million	Business Unit Leadership
\$1 million to \$10 million	Capital Review Committee
Over \$10 million	Executive Leadership Team or Board of Directors

A consistent digital approval workflow is enforced through authorized platforms, such as ERP systems (SAP, Oracle, Workday) or workflow tools (DocuSign, ServiceNow), to maintain auditability and regulatory compliance. Each project receives a unique CapEx identifier (unique ID) at inception, which ties together all stages of the investment lifecycle: from IBC documentation and budget approvals to execution tracking, capitalization in accounting systems, and post-implementation review. This unique ID simplifies tracking. It also helps other groups share and make getting ready for checks easier.

The Delegation of Authority list is now integrated into the workflow automation paths, allowing work to be assigned automatically based on the value of a project, its risk, and ESG factors; no approvals are required beyond preset limits. Having electronic approvals, risk-based rules for escalation, and lifecycle tracking all in one place reduces manual mistakes for companies, increases visibility, and accelerates decision-making at every step in the capital investment process.

3.6. Capital Project Prioritization

Capital expenditure decisions occur in a competitive setting where firms must allocate limited financial resources to the most strategically relevant and value-generating initiatives. In large and complex portfolios, this process requires a structured approach.

Projects are classified by investment type (e.g., growth and efficiency, maintenance, or compliance), business unit, geography, and strategic themes such as digital transformation or ESG. This methodical segmentation enables consistent monitoring of performance across categories and subcategories, while also underpinning the fine-targeted deployment of capital toward areas of highest strategic relevance.

Capital project prioritization uses tools such as value-versus-risk matrices to rank projects based on expected returns, risk exposure, and key performance indicators. These frameworks help identify underperforming or high-risk proposals early and enable transparent trade-offs during capital allocation. Priorities are reviewed on a rolling basis to reflect updated assumptions, refine rankings, and redirect funding toward higher-ranked initiatives.

Portfolio dashboards consolidate key performance measures, including ROI, IRR, NPV, strategic alignment scores, execution effectiveness, and risk levels. Real-time insights into the capital portfolio enable timely adjustments of investment priorities to match changing company goals. These dashboards also support transparent reporting and ongoing tracking of investment outcomes.

Capital project prioritization must take into account the organization's funding capacity and financial constraints. Input from Finance on internal and external funding sources, expected interest costs, and liquidity forecasts informs the timing and sequencing of capital releases. This ensures alignment between investment priorities, financial sustainability, and broader macroeconomic conditions.

Capital project prioritization ranks projects based on strategic relevance, expected returns, key performance indicators, risk exposure, and available funding. This ensures that capital is allocated to the most viable and strategically aligned initiatives.

3.7. System Setup Structure

A scalable CapEx governance model relies on integrated digital systems that enforce standardization, traceability, and compliance covering the full investment lifecycle, from idea intake to post-implementation review. **Table 5** summarizes how each phase of the CapEx lifecycle is digitally enabled to ensure governance consistency, financial control, and strategic alignment.

Table 5. Digital functions and governance across CapEx lifecycle stage (compiled by author).

Lifecycle Stage	Digital Function	Governance Enablement
1. Idea Intake & IBC Development	Structured templates, intake portals, early strategic and ESG tagging, unique ID creation	Standardizes proposal intake, ensures early alignment with strategy and ESG, and links projects to unique IDs for traceability
2. Delegation of Authority & Approvals	Automated routing, digital signatures, Gate-linked workflows	Enforces predefined thresholds, prevents unauthorized approvals, and ensures full auditability through digital logs
3. Planning, Forecasting & Budgeting	Scenario modeling, rolling forecasts, CapEx/OpEx treatment, treasury alignment	Supports dynamic capital planning; enforces correct accounting treatment and aligns funding with enterprise liquidity
4. Execution Tracking & Cost Control	Real-time budget monitoring, phase-based cost breakdowns, overrun alerts	Provides early visibility into cost or schedule deviations and allows proactive mitigation through automated tracking
5. Post-Implementation Review	Automated variance reports, performance tracking (IRR, NPV, ESG)	Measures actual vs. expected performance, informs portfolio recalibration, and embeds lessons learned into governance
6. Portfolio Dashboards & Analytics	BI dashboards by unit and geography, unique ID-based metrics	Enables real-time visibility into portfolio performance, supporting strategy-aligned capital reallocation
7. Data Integration & Metadata Governance	APIs, workflow engines, master data governance	Maintains data integrity across systems; ensures consistent classification and audit readiness

To enable these digital governance functions, organizations typically adopt one of two integration architectures tailored to their specific enterprise systems, regulatory requirements, and operational scale. Enterprises often choose between tightly integrated SAP-centric architectures, which embed compliance modules,

full audit capabilities, and real-time consistency, and modular or hybrid models that connect best-of-breed platforms via APIs and robotic process automation (Nendrambaka, 2024).

SAP-based solutions are well-suited for capital-intensive, highly regulated sectors. These organizations utilize SAP tools to manage the entire lifecycle of capital projects, from idea intake and approvals to execution tracking and reporting. SAP modules support consistent data structures, enforce compliance, and ensure audit readiness. This approach offers strong control and standardization, which is particularly useful where governance requirements are high.

In contrast, modular approaches offer greater flexibility and a better user experience for agile, innovation-driven, or geographically dispersed organizations. These firms often combine different platforms linked through middleware, APIs, or robotic process automation. While this model requires more coordination, it offers greater flexibility and a better user experience. Success with this approach depends on maintaining clear rules for data consistency and approval logic across platforms.

In practice, the level of ERP integration varies widely. Not all companies utilize a full ERP suite, and many still rely on spreadsheets or disconnected systems, particularly for smaller projects or early-stage evaluations. These setups can still support effective governance, provided that clear procedures, standardized templates, and documented approval thresholds are in place. The framework is designed to accommodate this variability, offering a flexible structure that can scale with digital maturity.

In both cases, the goal is a seamless digital environment that accelerates decision-making, enforces governance discipline, and aligns capital deployment with strategic objectives.

3.8. Post-Implementation Analysis and Reporting

Effective post-implementation analysis is a critical component of capital governance, as it captures the actual effectiveness of projects, identifies lessons learned and insights for continuous improvement, and supports portfolio recalibration.

A robust post-implementation analysis framework begins with assigning each capital project a unique ID that ties together all documentation, approvals, and financial records. Finance teams record capitalized costs monthly following applicable accounting standards and reconcile them at the project level across the balance sheet and cash flow statements.

During project execution, finance and project teams generate monthly reports to compare actual cash flows, capital expenditures against approved budgets, and planned timelines. High-risk or time-sensitive projects often undergo weekly or biweekly operational cost reviews. These reviews focus on key metrics, detailed variance explanations, which include scope changes, schedule shifts, contractual issues, and macroeconomic factors, to support timely escalation and corrective actions. Cumulative performance is reviewed quarterly with the aid of standard

templates that facilitate cross-project benchmarking and help embed lessons learned into governance practices, resulting in improved forecasting accuracy and strategic capital deployment protection.

Post-implementation reviews assess projects against approved cost baselines and timeliness to ensure achievement of the stated financial metrics (ROI, NPV, IRR), as well as strategic and ESG objectives. The routine use of these reviews enhances both capital effectiveness and institutional learning, with improved transparency in reporting outcomes, as well as the identification of areas for governance improvement. Results are consolidated into portfolio-level dashboards that provide executives with clear insights into project performance, lessons learned, and opportunities for improving future decision-making.

In alignment with evolving stakeholder and regulatory expectations, organizations are now integrating ESG and sustainability disclosures into their post-implementation reporting. By tagging green or socially focused projects at intake and validating those classifications before project completion, CapEx systems can accurately report the proportion of “Green” investments, contributions to social responsibility goals, and progress toward net-zero commitments. This end-to-end integration of tracking, reporting, and analysis ensures that capital investments deliver intended value, maintain financial accountability, and generate actionable insights for continuous improvement across the investment lifecycle.

3.9. CapEx Tools, Templates, and Governance Standards

A scalable CapEx management framework depends on standardized tools, templates, and digital workflows to embed governance discipline across the investment lifecycle. By tagging each investment with a unique ID and enforcing master data governance, organizations can enable traceability from concept through closeout; maintain consistent categorization across accounting, project management, and procurement systems; and preserve audit trail integrity. Standard IBC templates require assessment of NPV, IRR, discounted payback calculations, scenario models, risk registers, and ESG metrics, thereby reducing variability in proposal quality and enabling objective comparisons between projects. Uniform financial modeling standards mandate the use of corporate discount rates, inflation assumptions, tax treatments, scenarios, and sensitivity analyses.

Strategic alignment scorecards complement financial templates by weighting proposals according to enterprise priorities, sustainability targets, and risk-adjusted returns, enabling finance and strategy teams to prioritize initiatives that deliver the greatest strategic benefit. These measures collectively strengthen forecasting robustness and support transparent decision-making.

Phase-gate approval workflows integrate automated routing, digital signatures, and Delegation of Authority matrices to enforce governance thresholds at each investment gate. By linking approvals directly to ERP budget controls, the system prevents unauthorized commitments and ensures that no financial expenses occur without a validated business case.

Portfolio scoring dashboards aggregate data from IBCs and alignment models to present real-time value-risk tradeoffs, ESG scores, and strategic fit across the capital portfolio, empowering executives to dynamically rebalance investments.

Post-implementation analysis is driven by variance-tracking dashboards that connect original budgets to actual costs, categorizing deviations by scope, timing, or price drivers. Structured review templates standardize assessments of realized NPV, IRR, schedule performance, and ESG outcomes, archiving lessons learned for future governance improvements. By tagging ESG-relevant projects at the earliest gates and validating those classifications upon completion, organizations can accurately report on green investments, carbon reduction contributions, and social impact, aligning CapEx disclosures with net-zero commitments and regulatory expectations.

3.10. R&D Projects: Agile Governance for Non-Capitalized Innovation Investments

Under US GAAP, most research and development expenditures are recognized as expenses when incurred, with capitalization permitted only for internal-use software that has progressed beyond its preliminary stage. In contrast, IFRS allows development costs to be capitalized once technical and commercial feasibility, as well as reliable measurement criteria, are met (Zielhoff & Wojtanek, 2025). Despite these accounting differences, R&D initiatives demand governance rigor equivalent to CapEx projects, given their material resource requirements and strategic importance.

R&D project governance has several distinctive characteristics that set it apart from traditional capital expenditure practices. First, it operates with a higher degree of flexibility, embracing uncertainty, continuous learning, and the need to adapt direction based on early-stage failures or new information. Organizations continuously evaluate project performance and use this feedback to adjust R&D priorities, reallocating resources toward initiatives that demonstrate stronger outcomes or strategic fit. Second, investment decisions in R&D are often made using a portfolio approach, as firms assess sets of interrelated projects together to ensure consistency with their technological strategy and long-term objectives. This approach supports coordinated development and cross-project synergy under conditions of uncertainty and complexity (Hsuan, 2000).

Adapting a CapEx governance framework to R&D begins with a strategic intake process, where Gates 0 - 1 filter projects based on technology focus, innovation themes, and intellectual property potential. Although formal capitalization may not be applicable, each R&D proposal must include a lean investment business case outlining tested hypotheses, key performance indicators, and resource needs. Funding is released through OpEx governance, but it is tied to structured milestones analogous to capital gates, enabling decision points to continue, pivot, or terminate based on evolving evidence. Financial models include effectiveness metrics assessments, such as ROI, NPV, IRR, R&D Intensity Ratio, or Success Ratio.

Execution follows agile oversight, with frequent revalidation of objectives and resource allocation. Post-implementation reviews evaluate time-to-market achievements, realized innovation outcomes, including new patents or revenue streams, and alignment with strategic goals. This feedback is incorporated into portfolio models to refine priorities and funding levels, reinforcing a risk-distributed approach that accepts early-stage failures as an inherent part of the innovation.

R&D governance thus combines the structural discipline of CapEx models with the flexibility needed for exploratory investment. By embedding strategic filters, milestone-based funding, agile execution controls, and structured post-mortems into R&D processes, organizations gain transparency into innovation portfolios, link funding to evolving risk-return profiles, and drive continuous learning. This ensures that non-capitalized initiatives benefit from the same accountability and performance oversight that underpin successful capital expenditure governance.

4. Conclusion

This work presents a scalable and comprehensive CapEx management framework that unifies strategic alignment, phase-gated governance, digital automation, and standardized investment evaluation across the full investment lifecycle. By replacing fragmented processes and opaque decision-making with standardized evaluation procedures and a multi-tiered approval architecture, the model ensures consistency and strategic coherence across projects of varying scale and sector.

A potential limitation of this unified approach is that, by covering the full CapEx lifecycle, the framework may offer only a high-level treatment of specialized domains, such as advanced financial modeling techniques, ESG reporting, or complex ERP customizations, which often require tailored models, dedicated methodologies, or domain-specific tools. Organizations operating in complex regulatory or technical environments may need to supplement the model with internal policies, specialized toolkits, or external standards and expert guidance for these areas. Additionally, the framework does not include detailed templates such as standardized business case formats, risk registers, or Delegation of Authority matrices. These materials are typically developed in-house to align with an organization's systems, processes, and terminology. Future work should focus on developing a supporting library of customizable tools and playbooks to help organizations operationalize the model more effectively while maintaining both comprehensive governance and domain-specific depth.

A key part of the system is its organized phase-gate review, in which each stage (Pre-Gate, Gates 0 - 3) defines specific deliverables to be completed, financial and risk thresholds, and guidelines for decision-making. Online submission forms, seamless integration with ERP system, and automatic approvals routing ensure visibility, the ability to track changes, and quick-fix steps when there are differences in budget or timetable. For agile or R&D-focused projects, a lighter, milestone-based approach with iterative retrospectives and business-case recalibrations supports rapid learning cycles and strategic flexibility.

Central to effective governance is the unified Investment Business Case, which combines strategic filters with disciplined DCF analysis, scenario modeling, and quantitative risk assessment. A Delegation of Authority matrix and standard digital templates prevent unauthorized spending and simplify audits. After the project ends, post-implementation reviews assess the planned versus actual performance indicators, including ROI, NPV, IRR, and ESG results. The results are presented in dashboards for the entire portfolio. This helps with ongoing learning and enhances the process.

The framework relies on standardized tools and templates to ensure data integrity and procedural consistency across all phases of the project. Data initiatives are also typed and placed on a value versus risk matrix; rolling forecasts allow organizations to implement a dynamic mechanism for portfolio optimization and capital reallocation. Supporting both centralized, SAP-centric, and hybrid, modular system architectures enables scalability and ease of adoption in various corporate environments.

Effective CapEx management leads to better investment decision-making, lower financial risk, and improved strategic alignment. Organizations implementing this framework will have the capability to systematically implement best practices in capital governance, achieving targeted improvements in cost savings and project performance metrics.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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