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Integrating Risk, Stakeholder, and ERP-BPMS Approaches: A Cross-Sectoral Multi-Case Study in Project Management

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Abstract. *This study investigates how the integration of real-time risk monitoring, stakeholder engagement, and multicriteria decision analysis (MCDA) within an enterprise resource planning and business process management system (ERP-BPMS) enhances project governance and promotes stakeholder well-being across utilities, construction, water technology, and energy services. It addresses the shortcomings of fragmented risk management and sporadic stakeholder consultation. A convergent mixed-method, multiple-case study was conducted over 18 months using ERP-BPMS logs, standardized surveys (812 responses), and semi-structured interviews (8-12 participants per organization). One utility provider employed a quasi-experimental design to compare the pilot and control districts. The MCDA parameters were refined through Delphi workshops to accommodate for sector-specific priorities. Documented managerial overrides provide context-sensitive refinements for algorithmic recommendations. The integrated approach reduced response times by 25-35%, increased preventive actions by 14-23 percentage points, and increased stakeholder satisfaction by 8-12%. Continuous stakeholder dialogue enabled proactive risk mitigation, as evidenced by 29% fewer service callbacks in the water technology sector. Managerial overrides (13-20%) ensured that local knowledge shaped the final decisions. The framework improves resource allocation, minimizes operational disruptions, and supports sustainable and inclusive governance. By operationalizing dynamic capabilities – risk sensing, MCDA-driven seizing, and stakeholder-led reconfiguring – this study advances the project management and stakeholder theories. This demonstrates that sustained digitally enabled engagement yields measurable gains in community welfare and organizational resilience. The cross-sector model offers a scalable blueprint to balance technical efficiency and social responsibility under tight resource constraints.*

Keywords: *ERP-BPMS integration, Project governance, Stakeholder engagement, Risk management, Multi-criteria decision analysis, Stakeholder well-*

being, Dynamic capabilities, Sustainable project management, Operational resilience, Real-time analytics, Preventive actions, Cross-sector collaboration.

Інтеграція підходів до управління ризиками, зацікавленими сторонами та ERP-BPMS: міждисциплінарне дослідження в управлінні проєктами

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Анотація. *У цьому дослідженні розглядається впровадження інтегрованого підходу до управління проєктами, що передбачає синергію між моніторингом ризиків у реальному часі, активною участю зацікавлених сторін та застосуванням багатокритеріального аналізу рішень (MCDA) у рамках цифрових систем ERP-BPMS. Основна мета полягає у покращенні ефективності управління проєктами та забезпеченні добробуту зацікавлених сторін у секторах комунальних послуг, будівництва, водопостачання та енергетики. Дослідження усуває недоліки, пов'язані з фрагментованим підходом до управління ризиками та нерегулярною взаємодією із зацікавленими сторонами. Упродовж 18 місяців реалізовувалося конвергентне змішане методологічне дослідження з елементами багатоаспектного аналізу випадків, що включало опрацювання даних з ERP-BPMS систем, стандартизовані анкетування (812 респондентів) та напівструктуровані інтерв'ю (по 8-12 представників з кожної організації). Один з операторів комунальних послуг провів квазіексперимент, що дозволив порівняти результати між контрольним та пілотним регіонами. Формування критеріїв для MCDA здійснювалося через Delphi-семінари з урахуванням галузевих пріоритетів. Отримані дані дозволили реалізувати коригувальні управлінські дії, що сприяли адаптації алгоритмічних рішень до конкретних умов. Інтеграція методів управління сприяла скороченню часу реагування на інциденти на 25-35%, зростанню частки превентивних заходів на 14-23 відсоткові пункти та підвищенню рівня задоволеності серед зацікавлених сторін на 8-12%. Постійна комунікація з учасниками процесу управління дозволила знизити ризики проактивним шляхом, що підтверджується зменшенням кількості повторних звернень на 29% у сфері водних технологій. Управлінські втручання (у діапазоні 13-20%) забезпечили ефективне залучення локальних знань до процесів ухвалення рішень. Запропонована модель сприяє оптимізації розподілу ресурсів, зниженню операційних збоїв і підтримує концепцію сталого та інклюзивного управління. Завдяки реалізації концепції динамічних можливостей – виявлення ризиків, ухвалення рішень із*

застосуванням MCDA та реконфігурація системи за участі зацікавлених сторін – дослідження вносить вклад у розвиток теоретичних підходів до управління проєктами та взаємодії з зацікавленими сторонами. Результати доводять, що цифрова взаємодія, яка ґрунтується на сталій комунікації, забезпечує вимірні переваги як для організаційної стійкості, так і для соціального добробуту. Представлена міждисциплінарна модель є універсальною та масштабованою, що дозволяє знаходити баланс між технічною результативністю й соціальною відповідальністю в умовах обмежених ресурсів.

Ключові слова: *інтеграція ERP-BPMS, управління проєктами, залучення зацікавлених сторін, управління ризиками, багатокритеріальний аналіз рішень, добробут зацікавлених сторін, динамічні можливості, стале управління проєктами, операційна стійкість, аналітика в режимі реального часу, превентивні дії, міждисциплінарна співпраця.*

Introduction. Organizations across diverse industries face escalating demands to deliver complex projects, while sustaining stakeholder well-being and operational resilience. Many large-scale initiatives, especially those involving enterprise systems or public-facing infrastructure, struggle with delays, budget overruns, and erosion of trust (Fatima et al. [1] and Willumsen et al. [2]). Studies suggest that project-driven firms frequently encounter repeated disruptions or cost escalations owing to fragmented risk management and underutilized data (Xia et al. [3]; Ghanbari et al. [4]). These outcomes threaten long-term sustainability and intensify the need for governance models that integrate real-time intelligence with stakeholder-centric approaches (Wojewnik-Filipkowska et al. [5]; Araújo Lima et al. [6]; Chernenko & Teslenko [7]). Chernenko and Teslenko's [7] recent work with housing and communal service providers demonstrates the operational benefits of integrating stakeholder management with risk methods, particularly relevant for utilities such as Case Company A. Similar insights have emerged in cross-sector partnerships, where Jokiel et al. [8] identified

that integrative project management approaches yield enhanced outcomes through structured stakeholder engagement protocols.

Recent research in project management underlines the importance of three interrelated factors: systematic risk assessment, stakeholder engagement, and adaptive project prioritization (Ali & Haapasalo [9]; Micán et al. [10]). Traditional risk protocols often rely on static registers that miss fluid operational signals, leaving managers reactive rather than proactive (Willumsen et al. [2]). Stakeholder theory emphasizes continuous dialogue to align organizational actions with stakeholder expectations; however, many firms reduce their engagement with sporadic consultations that overlook evolving needs (Freeman, 1984 [11]; Santos & Fernandes [12]; Uribe et al. [13]). This connection between stakeholders and broader organizational goals has been further explored in the relevant literature. For instance, Uribe et al. [13] specifically highlighted the symbiotic relationship between stakeholder theory and sustainability in project management contexts. Simultaneously, multi-criteria decision analysis (MCDA) has emerged as a structured means of ranking projects (da Silva et al. [14]; Więckowski et al. [15]), although standalone MCDA applications rarely incorporate real-time risk data or stakeholder insights (de Souza et al. [16]; Aghajani et al. [17]. Więckowski et al. [15] provided a comprehensive review of recent MCDA applications and trends across various domains, highlighting their growing importance in complex decision environments. Despite these advances in MCDA applications, the separation between risk monitoring, stakeholder engagement, and MCDA weakens their collective effectiveness, especially when budgets are tight and sudden disruptions can force rapid decision making (Bošnjak & Jajac [18]).

Scholars have increasingly proposed integrating risk monitoring, stakeholder feedback, and MCDA within a single digital environment. Enterprise resource planning and business process management systems (ERP-BPMS) can unify data streams, automate routine tasks, and offer dashboards that display updated metrics (Eichhorn & Tukel [19]; Chernenko et al. [20]). While ERP-BPMS platforms offer significant potential for integration, prior studies report partial success in linking risk management

with selected stakeholder feedback or applying MCDA to subsets of projects, yet these efforts rarely yield a truly holistic framework (Kuura & Lundin [21]; Cvijović et al. [22]). Organizations often maintain separate silos for risk documentation, stakeholder communication, and project prioritization, which delays critical interventions when anomalies appear (Patrício et al. [23]; Barbati et al. [24]). This gap persists across sectors, ranging from utilities to technology services, limiting both theoretical understanding and practical insights (Dandage et al. [25]).

Few empirical investigations have addressed how all three elements—risk analytics, stakeholder engagement, and MCDA-based selection—can converge in an ERP-BPMS platform. Researchers have examined risk-stakeholder relationships (Xia et al. [3, 26]) or MCDA without continuous stakeholder input (Ghanbari et al. [4]), but rarely simultaneously under real-time data conditions. Xia et al. [26] specifically demonstrated how construction project contractors can mitigate risks through strategic management of stakeholder attributes, providing evidence for the operational benefits of this integration. This absence hinders the advancement of the dynamic capabilities theory, which centers on sensing, seizing, and reconfiguring resources in turbulent environments (Hermano & Martín-Cruz [27]; Barbosa & Carvalho [28]). It also restricts the practical application of stakeholder theory by overlooking how digital infrastructure might capture evolving stakeholder perspectives (Lyulyov et al. [29]). Addressing this gap is essential for managers seeking sustainable project outcomes, as disjointed approaches risk missing subtle warning signals or underestimating stakeholders' concerns in critical decisions (Bechtel et al. [30]).

This study explores how four organizations integrate real-time risk monitoring, stakeholder collaboration, and MCDA-driven prioritization within an ERP-BPMS. To maintain anonymity, these firms were named Case Company A, Case Company B, Case Company C, and Case Company D. Case Company A is a utility provider grappling with aging pipelines and frequent service interruptions. Case Company B is a specialized construction enterprise managing geographically dispersed sites under tight deadlines. Case Company C is a data-driven water technology firm that aims to

optimize resource usage. Case Company D is an energy service organization operating under strict regulatory control. All four adopted a customized ERP-BPMS that collects risk indicators in real time, channels stakeholder feedback into daily workflows, and automates project selection through the MCDA. This study addresses three questions. First, do merging risk analytics, stakeholder input, and MCDA in an ERP-BPMS significantly improve operational efficiency and decision speed (RQ1)? Second, how does this unified approach affect project ranking and resource allocation when budgets are constrained (RQ2)? Third, does embedding continuous stakeholder engagement through a digital platform lead to higher cost-effectiveness and satisfaction among internal teams and external clients (RQ3)?

This study makes several contributions to the literature. Theoretically, it demonstrates how a single digital platform operationalizes dynamic capabilities by enabling organizations to sense risk signals, seize decision opportunities through MCDA, and reconfigure priorities in response to stakeholder feedback (Killen & Hunt [31]). It expands stakeholder theory by showing that ongoing engagement, rather than sporadic consultations, can generate measurable benefits for project outcomes and user satisfaction (Freeman [10]; Micán et al. [11]). It also refines MCDA applications by illustrating how real-time data can inform algorithmic rankings and structured overrides (Aghajani et al. [17]). Practically, it offers managers an integrative framework that unites risk management, stakeholder relations, and prioritization in contexts as varied as infrastructure modernization, specialized construction, water technology, and energy compliance. The remainder of this article outlines the multi-case methodology, details the comparative results, discusses implications for theory and practice, and concludes with recommendations for future directions for holistic digital frameworks in project governance.

Materials and Methods. This study uses convergent mixed-methods, multiple-case design to examine how an integrated project governance framework, based on real-time risk monitoring, structured stakeholder engagement, and multi-criteria decision analysis (MCDA), operates within a unified enterprise resource planning and

business process management system (ERP-BPMS). Four anonymized organizations participated: Case Company A (a utility service provider), Case Company B (a specialized construction firm), Case Company C (a water management technology company), and Case Company D (an energy services corporation). Each had introduced or upgraded an ERP-BPMS in the two years before data collection, which ran from January 2023 to June 2024. All four companies met three inclusion criteria: they employed more than 100 staff or managed annual project portfolios exceeding one million dollars; they were open to data sharing and in-depth interviews; and they faced comparable operational challenges in coordinating multi-project portfolios under resource and risk constraints. Despite working in distinct sectors, they shared a sufficiently similar need for systematic scheduling, risk mitigation, and stakeholder collaboration to support meaningful cross-case analysis [32].

Research Design. A multiple-case study approach was selected to capture the contextual details that shape how an integrated digital framework unfolds in actual organizational settings [33]. This design fits complex environments in which risk tracking, stakeholder inputs, and algorithmic scoring intersect [27]. Instead of aiming for broad statistical generalizability, this study pursued analytical generalization through cross-case comparisons [30]. A convergent mixed-methods strategy aligned well with this objective, merging quantitative indicators (system logs and surveys) and qualitative insights (interviews) to yield a holistic assessment of the framework's impact on efficiency, prioritization, and stakeholder satisfaction [32]. Case Company A included a quasi-experimental element by piloting the new MCDA-based prioritization in one district, contrasting it with three districts that continued pre-existing procedures [34]. This setup allowed for more robust internal checks of the effectiveness of the intervention.

Figure 1 presents the conceptual framework of our integrated approach, illustrating risk monitoring, stakeholder engagement, and the MCDA-based prioritization function within the unified ERP-BPMS platform across the four case companies.

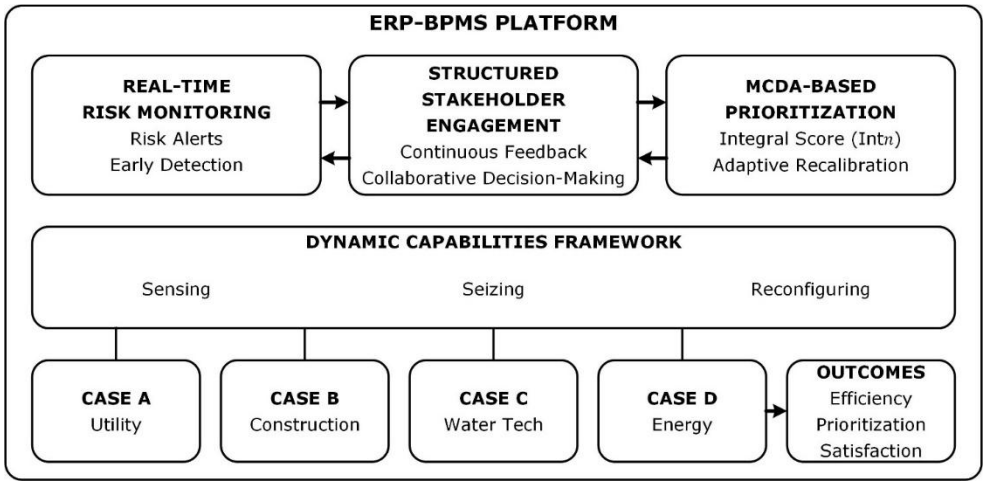

Figure 1. The unified ERP-BPMS platform across the four case companies

The diagram illustrates three core components (real-time risk monitoring, structured stakeholder engagement, and MCDA-based prioritization) and their interconnections within the ERP-BPMS platform. These components operationalize the dynamic capabilities of sensing, seizing, and reconfiguring across all four case companies (utility, construction, water technology, and energy services), leading to improved operational efficiency, project prioritization, and stakeholder satisfaction.

Data Collection. Data were gathered between January 2023 and June 2024 from three primary sources. The first source comprised system logs extracted from each organization's ERP-BPMS, offering objective measures of task duration, cost deviation, resource allocation, and recorded risk events. Six to twelve months of pre-implementation logs established baselines, whereas up to 18 months of post-implementation data enabled longitudinal comparisons [35]. In Case Company A, logs were further disaggregated at the district level to observe the differences between the pilot and non-pilot regions.

The second source involved standardized surveys administered to employees, main clients, and, when relevant, regulatory stakeholders or partner firms. Questionnaires are built on established constructs in the project management literature, focusing on issues such as system usability, decision transparency, fairness, and overall satisfaction [11, 19, 25]. A total of 812 valid responses were collected, with internal

and partner response rates of 60–70% and 75%, respectively. Reliability checks demonstrated Cronbach's alpha values exceeding 0.80, and confirmatory factor analyses (CFA) confirmed factor loadings above 0.70, indicating robust measurement of the constructs [17].

The third source comprised semi-structured interviews that yielded detailed qualitative insights. Eight to twelve participants were interviewed in each organization, including managers, technical experts, and day-to-day users of ERP-BPMS. The sessions lasted between 60 and 90 min, were recorded with consent, transcribed verbatim, and coded by two independent researchers. Cohen's kappa values exceeding 0.80 indicated strong inter-coder reliability [36]. The combination of logs, surveys, and interviews enabled method triangulation, aligning with the recommended best practices for studying complex project management interventions [22].

New Model and Methods: MCDA Framework. The integrated framework hinges on an MCDA model embedded in ERP-BPMS, which calculates an integral score $Int_{(n)}$ for each proposed project or intervention. Recent research by [37] emphasized moving beyond traditional probability-impact matrices toward more quantitative methodologies for risk prioritization, an approach that aligns with our implementation. The model drew on prior MCDA research [38, 39, 40] but introduced specific inversions and ratio-based scaling to highlight cost-effectiveness. Valipour et al. [40] demonstrated the value of comparative MCDM method analysis for risk assessment in public-private partnership projects, an approach that informed our parameter selection. The mathematical formulation of the MCDA model is as follows (1):

$$\mathrm{Int_n} = \frac{\left[\left(\left(\mathrm{M}+1\right)-\mathrm{Cr_n}\right)+\left(\left(\mathrm{P}+1\right)-\mathrm{Sa_n}\right)\right]\cdot \mathrm{Se_n}\cdot \mathrm{Rloss_n}\cdot\left(\left(\mathrm{K}+1\right)-\mathrm{Rdel_n}\right)}{\mathrm{Cwork_n}}, \qquad (1)$$

here, Cr_n denotes criticality (1-4, with 1 as highest), Sa_n denotes safety risk (1-4), Se_n is seasonality (1.0-2.0), $Rloss_n$ indicates potential loss or damage if delayed, $Rdel_n$ reflects the risk of delay (1-4), and $Cwork_n$ is cost. Constants M, P, and K were each set to four, matching the four-level risk scales that prevailed in all four companies. Local experts affirmed that 1-4 scoring provided sufficient granularity and corresponded well to established matrices in standards, such as ISO 31000 [41]. A different constant can be substituted if organizations prefer a five- or three-point rating system; however, the Delphi workshops (discussed below) validated the 1-4 scale as optimal in these contexts.

Inverting the parameters ensures that a rating of "1" has a stronger influence on Int_n. For example, in Company A, a project with $Cr_1 = 2$, $Sa_1 = 1$, $Se_1 = 1.3$, $Rloss_1 = 1.5$, $Rdel_1 = 2$ and $Cwork_1 = 1000$ generated

$$Int_n = \frac{\left[(5-2)+(5-1)\right]\cdot 1.3\cdot 1.5\cdot (5-2)}{1000} = 0.041.$$

This integral score compares similar figures for other projects. A higher Int_n implies higher priority, although in all four organizations, managers retained discretion to override the system if unexpected circumstances surfaced [29]. These overrides were recorded within the ERP-BPMS to permit iterative refinement of the model.

Delphi Expert Calibration

Parameter values and local modifiers (e.g., a "community impact" factor in Company A, "regulatory urgency" in Company D, "seasonality multiplier" in Company B, "technology readiness" technology readiness' in Company C) were calibrated using a modified Delphi method [42]. Delphi's iterative and anonymous structure is preferred over methods such as the Analytic Hierarchy Process or Nominal Group Technique because it accommodates geographically dispersed experts and reduces the influence of dominant voices [43]. Each company formed a panel of six to

eight experts with at least five years of experience and roles spanning the technical, financial, or operational domains. Round 1 required each expert to rate the key parameters using 12-15 representative historical projects. Aggregated results were presented in round 2, prompting experts to revise their input if they found the group consensus to be persuasive. The third round ensued only when Kendall's coefficient of concordance (W) remained below 0.75. Final Kendall's W values ranged from 0.77 to 0.85 across the four organizations, signifying strong inter-expert alignment [44]. Company B's team, for example, prioritized seasonal constraints owing to construction windows, while Company C's panel introduced a moderate emphasis on advanced sensor readiness. Company D placed added weight on compliance factors and Company A adjusted for large-scale community disruptions. This process balances each firm's unique requirements with the shared MCDA logic.

Validation and Sensitivity Analysis

Quantitative Validation. Survey-based constructs yielded Cronbach's alpha values exceeding 0.80, and factor analyses showed loadings above 0.70, confirming robust reliability and validity [17]. The MCDA model's predictions were compared with actual managerial decisions in the 12–36 months preceding the study. Mean squared error metrics of approximately 0.20–0.24 indicated moderate alignment. In Company A's quasi-experimental scenario, one pilot district applied the MCDA approach, while three control districts followed legacy methods, permitting a MANOVA to compare performance metrics. Significant differences ($p<0.05$) in cost and timing outcomes suggest a causal contribution from the MCDA system [34].

Qualitative Validation. Interviews highlight stakeholder reactions to risk inversions and cost weighting [36]. Many respondents emphasized improved transparency, as the ERP-BPMS displayed prioritized tasks on a user-friendly dashboard. Triangulation across system logs, surveys, and interviews reinforced that the integrated approach fostered a better alignment of resources with emerging risks, although overrides remained essential for unanticipated factors [22]. The synergy

between structured scoring and stakeholder input has been consistently cited as a key advantage.

Sensitivity Analysis. Each organization assessed ±20% quarterly parameter variations for 20–25 projects. Rankings for top interventions changed by at most two to three positions (<5%) in each test, verifying that small shifts in parameter values did not dramatically alter prioritized lists [45]. Potential loss $Rloss_n$ tended to have the greatest effect on ranks, whereas seasonality Se_n was the least influential. Although no formal table is included here, the supplementary data illustrate these modest fluctuations and confirm the stability of the MCDA-driven recommendations.

Ethical Considerations

All participants received detailed information about the study's scope, data management procedures, and confidentiality measures, and they provided written informed consent. The project involved organizational processes rather than sensitive personal data; therefore, formal ethics board approval was not mandatory, although the research adhered to recognized ethical norms (COPE). Company names, locations, and proprietary financial details were omitted, protecting the anonymity of Cases A, B, C, and D. Each firm had the opportunity to review a factual summary of its findings to ensure accuracy and maintain trust [46]. Data were stored securely with access restricted to the research team, and respondents were free to withdraw at any stage without consequences. This framework of anonymization, secure data handling, and voluntary participation aligns with best practices in project management research [11].

Data Analysis

Quantitative data from the system logs and surveys were analyzed using SPSS (version 29). Descriptive statistics (e.g., means and standard deviations) summarized performance indicators, while paired t-tests or repeated-measures ANOVAs tested pre- vs. post-implementation differences at $p<0.05$. Nonparametric alternatives (Wilcoxon signed-rank) were used for nonnormal distributions. Structural equation modeling explored whether MCDA-driven risk scores predicted perceived stakeholder

satisfaction or fairness, with model fit assessed using CFI (>0.90), RMSEA (<0.08), and SRMR (<0.08) [47]. The effect sizes (Cohen's d) contextualized the practical relevance of statistical significance.

Qualitative data from the interviews were coded inductively following thematic analysis guidelines [36]. Two independent researchers assigned initial codes and reconciled the differences to create a unified scheme. Cohen's kappa exceeded 0.80, suggesting high inter-coder agreement. The themes included "risk-based decision transparency", "stakeholder override processes", "cost-driven prioritization", and "regulatory constraints". Triangulating these themes with quantitative metrics allows deeper insight into how the MCDA formula, stakeholder feedback, and real-time data streams shape decisions in each case [6].

Cross-case comparisons [33] identified both common benefits, such as improved documentation of risks, and unique variations, such as Company D's emphasis on regulatory factors or Company B's reliance on seasonal windows for construction tasks. These differences highlight the importance of tailoring the MCDA to local needs through Delphi calibration. The quasi-experimental element in Company A further supported causal inferences by contrasting districts with and without the new prioritization approach. This multi-method methodology provides a strong platform for linking risk-based algorithms with stakeholder well-being, which is consistent with the aims of the International Journal of Managing Projects in Business [29, 31].

These methods outline how data were collected from multiple sources, how the MCDA model was derived and validated, and how the ethical and analytical frameworks were applied. The following section presents the empirical findings, demonstrating how real-time risk alerts, stakeholder-engaged scoring, and cost-efficiency metrics jointly influence project outcomes across the four participating organizations.

Highlighting previously unresolved parts of the overall problem. This study uses convergent mixed-methods, multiple-case design to examine how an integrated project governance framework, based on real-time risk monitoring, structured

stakeholder engagement, and multi-criteria decision analysis (MCDA), operates within a unified enterprise resource planning and business process management system (ERP-BPMS). Four anonymized organizations participated: Case Company A (a utility service provider), Case Company B (a specialized construction firm), Case Company C (a water management technology company), and Case Company D (an energy services corporation). Each had introduced or upgraded an ERP-BPMS in the two years before data collection, which ran from January 2023 to June 2024. All four companies met three inclusion criteria: they employed more than 100 staff or managed annual project portfolios exceeding one million dollars; they were open to data sharing and in-depth interviews; and they faced comparable operational challenges in coordinating multi-project portfolios under resource and risk constraints. Despite working in distinct sectors, they shared a sufficiently similar need for systematic scheduling, risk mitigation, and stakeholder collaboration to support meaningful cross-case analysis [32].

Results. Data were gathered between January 2023 and June 2024 from four anonymized companies that implemented an integrated enterprise resource planning and business process management system (ERP-BPMS) to unify risk monitoring, stakeholder collaboration, and multi-criteria project prioritization. These organizations, referred to here as Case Company A (utility services), Case Company B (specialized construction), Case Company C (water management technology), and Case Company D (energy services), experienced fragmented data and reactive decision making before the new framework. All numerical indicators draw on matched pre- and post-implementation comparisons of operational logs, staff surveys, and semi-structured interviews. Statistical outputs include means, standard deviations (SD), p-values, effect sizes (e.g., Cohen’s d, partial η^2), and 95% confidence intervals, where applicable. Each table is introduced in the text, bears a concise title, and includes a note clarifying that the data belong to the authors and were collected under this study’s protocol. The broader interpretations are presented in the following sections.

RQ1 Findings: Integration Effects on Operational Efficiency and Decision-Making

Baseline Conditions. All four companies relied on unconnected databases and incomplete risk logs prior to ERP-BPMS deployment. Table 1 summarizes these pre-implementation conditions, spanning six to 12 months. The field staff in Case Company A recorded only a fraction of minor leaks, while Case Company D maintained separate systems for regulatory versus maintenance tasks. Case Company B struggled to coordinate design updates across decentralized platforms, and Case Company C lacked feedback loops between development and service teams. Managers in each case reported reliance on urgent, last-minute decisions, reflecting 50–70% reactive interventions.

Table 1

Baseline Operational Characteristics in the Four Case Companies

Dimension	Case A (Utility)	Case B (Construction)	Case C (Water Tech)	Case D (Energy)
Information Systems	Multiple maintenance & finance DBs	Decentralized platforms	Disconnected development & support	Isolated compliance & customer systems
Risk Documentation (% tasks)	37% (SD=4.3; n=160)	44% (SD=3.8; n=125)	50% (SD=4.2; n=150)	40% (SD=3.0; n=140)
Reactive Resource Allocation	~73% triggered by urgent breakdowns	~66% driven by deadlines	~56% based on chronological requests	~51% siloed by department
Stakeholder Input Usage	~31% of feedback escalated	~41% of client ideas integrated	~36% feedback loop to development	~28% overlap in compliance vs. local

Note. Data belong to the authors, based on pre-implementation audits, interviews, and process reviews over 6–12 months. Percentages reflect documented tasks relative to total events. SD indicates sampling variability; n is the number of records analyzed.

A manager from Case Company A explained, “We recorded data, but it was incomplete and scattered. We mostly handled emergencies, so preventive actions were sidelined”. Interviews with other firms revealed similar difficulties, consistent with prior findings that siloed data restrict proactive risk management [2].

Post-Implementation Improvements. Centralizing maintenance requests, risk alerts, and stakeholder inputs through the ERP-BPMS shifted these companies toward quicker response times and greater preventive efforts. Table 2 shows the matched pre- and post-implementation metrics over 6–12 months, controlling for seasonal peaks. All p-values were two-tailed (α=.05), with effect sizes reported to indicate practical significance.

Field staff improved documentation practices following implementation, with the percentage of operational issues visible in systems ('Documented Field Issue Visibility') increasing substantially from baseline risk documentation levels.

Table 2

Operational Metrics Before and After ERP-BPMS Integration

Metric	Case A (Utility)	Case B (Construction)	Case C (Water Tech)	Case D (Energy)
Mean Response Time (pre → post)	1.9h → 1.3h (t(58)=5.27, p<.001, d=0.64)	4.2d → 3.1d (t(42)=4.11, p<.001, d=0.57)	27h → 20h (t(120)=5.62, p<.001, d=0.63)	3.4h → 2.5h (t(84)=5.02, p<.001, d=0.59)
Preventive Actions (pre → post)	25% → 47% (Δ=+22 p.p.; n=120)	30% → 44% (Δ=+14 p.p.; n=90)	22% → 42% (Δ=+20 p.p.; n=105)	29% → 52% (Δ=+23 p.p.; n=130)
Unplanned Interventions (% change)	–21% (p<.01)	–15% (p<.01)	–20% (p<.01)	–17% (p<.01)
Documented Field Issue Visibility (%)	40% → 85%	49% → 81%	55% → 88%	46% → 83%

Data compiled by the authors from ERP-BPMS logs; n denotes matched observations. p-values < .05 indicate statistically significant changes.
Note: 'Documented Field Issue Visibility' represents the percentage of operational issues that were visible in systems, whereas 'Risk Documentation' in Table 1 refers to the percentage of tasks with formal risk assessments attached.

Case Company A shortened the mean response times by approximately 32%, reducing repair intervals from 1.9 to 1.3 hours (Cohen’s d=0.64). Case Company B reduced delays by approximately 1.1 days. Case Company C decreased support durations by seven hours, and Case Company D moved from 3.4 to 2.5 hours for fault resolutions. preventive actions increased by 14–23 percentage points (p.p.), indicating a shift away from crisis-based allocation. A field technician in Case Company A

reported that “Seeing small leaks in the new system early means we fix them before major breakdowns”, echoing arguments that integrated data foster proactive management [4].

RQ2 Findings: Real-Time Data Integration and Project Prioritization

All firms employed a multi-criteria decision analysis (MCDA) routine within the ERP-BPMS to rank interventions by criticality, safety risk, seasonality, and potential loss. To provide a structured overview of how the MCDA approach was implemented across cases, Table 3 outlines these parameters and local modifications calibrated in expert workshops with six to eight stakeholders in each company. Kendall’s W values (0.77–0.85) confirmed strong agreement on weightings [44].

Table 3

MCDA Parameters and Local Adaptations

Parameter	Case A (Utility)	Case B (Construction)	Case C (Water Tech)	Case D (Energy)
Criticality (Cr_n)	1–4 scale (lower=high impact)	1–4 scale (lower=milestone risk)	1–4 scale (lower=essential node)	1–4 scale (lower=grid node)
Safety Risk (Sa_n)	Inverted 1–4 with field logs	Inverted 1–4 with environment	Inverted 1–4 with complexity	Inverted 1–4 with hazard
Seasonality (Se_n)	1.0–1.9 for peak usage	1.0–1.7 for weather	1.0–1.6 for water demand	1.0–1.9 for peak loads
Potential Loss ($Rloss_n$)	Service disruption + repair	Weighted client penalty	Cost + water savings	Reliability cost + regulation
Local Modifier	Community factor (1.0–1.3)	Resource complexity (1.0–1.4)	Tech readiness (0.8–1.2)	Regulatory urgency (1.0–1.4)

Note. Data belongs to the authors, recorded during expert calibration workshops. Sensitivity checks (±20% changes) shifted top-priority items by <5%.

Knapsack-style optimization ranked interventions according to the MCDA score-to-cost ratios. Table 4 shows resource allocation and managerial override patterns. Overrides occurred when supervisors revised algorithmic suggestions because of unmodeled factors (emergent client demands, abrupt weather risks, or community pressures).

Table 4

Resource Allocation Outcomes and Override Patterns

Organization	Allocation Mechanism	Key Outcomes (linked to Table 2)	Override Rate	Primary Override Motive
Case A (Utility)	Quarterly budget (~500k units)	~7% cost reduction; ~32% faster repairs	18%	Community-driven demands
Case B (Construction)	Score-based resource scheduling across sites	~20% drop in idle equipment; ~15% fewer delays	20%	Late client requirement changes
Case C (Water Tech)	MCDA-driven manufacturing and installation queue	25% shorter lead times; fewer system failures	13%	Strategic partnership factors
Case D (Energy)	CapEx-limited selection (balancing compliance/value)	16% higher reliability; ~26% faster responses	16%	Regulatory changes

Note. Data compiled by the authors from ERP-BPMS logs (12-month window). Override rates denote the fraction of algorithmically suggested items that were manually changed.

Case Company B showed the highest override rate (20%) owing to frequent shifts in client requests, whereas Case Company C's lower rate (13%) reflected more predictable installations. Sensitivity analyses revealed stable rankings, with ±20% parameter changes shifting the top items by only two or three positions. Managers described the MCDA routine as "a solid baseline," but noted that human discretion remained essential when facing sudden, unrecorded inputs.

RQ3 Findings: Stakeholder Engagement Effects on Resource Utilization and Satisfaction

All four companies integrated stakeholder review sessions into their daily ERP-BPMS workflows, capturing direct input from municipal leaders, clients, or partners. Table 5 outlines the engagement formats and key results, including satisfaction surveys and operational metrics.

Table 5

Stakeholder Engagement Frameworks and Observed Outcomes

Organization	Engagement Format	Frequency	Key Metrics	Observed Changes
Case A (Utility)	Monthly community forums	Monthly	Downtime, user satisfaction	+10% satisfaction ($t(249)=3.96$, $p<.001$); –20% downtime
Case B (Construction)	Bi-weekly project councils with clients/design	Bi-weekly	Timeline adherence, resource backlog	+12% client satisfaction ($t(38)=3.22$, $p<.01$); –25% backlog
Case C (Water Tech)	Monthly advisory panels with partners/end-users	Monthly	Installation quality, support callbacks	+9% satisfaction ($t(117)=4.62$, $p<.001$); –29% callbacks
Case D (Energy)	Quarterly reliability roundtables with regulators/community	Quarterly	Reliability index, complaint frequency	+8% consumer satisfaction ($t(385)=4.09$, $p<.001$); –26% complaints

Note. Data drawn from ERP-BPMS logs of stakeholder meetings, combined with standardized satisfaction surveys. $p < .05$ indicates significant improvement.

Case Company A attributed approximately 70% of major infrastructure updates to issues raised in monthly forums. A municipal liaison remarked, “We see actual maintenance action now, not just talk”. Case Company C re-ordered 35% of the MCDA-driven projects after partner input, cutting service callbacks by 29%. Such outcomes align with research suggesting that structured stakeholder dialogue fosters improved project decisions [22, 48]. Hwabamungu and Shepherd's [48] recent work in the UK construction industry demonstrated that strategic stakeholder involvement significantly influences the successful adoption of digital technologies, which is particularly relevant for Case Companies B and D's implementation experiences.

Challenges or Anomalies

Each firm encountered challenges in terms of data completeness and cultural barriers during the initial rollout. Legacy records showed 25–40% missing fields, requiring early “data integrity” efforts. Resistance was highest in Cases A and D (40–60%), although acceptance grew as staff observed fewer emergency incidents. Case B

recalibrated the MCDA parameters five times over nine months, reducing the override rates from an initial 36% to the current 20%, as shown in Table 4. Case C temporarily used manual data imports for approximately 20% of the early orders until stable integration with legacy manufacturing systems was established.

A quasi-experimental element in Case A compared a pilot district using an integrated approach with three districts that continued legacy practices. A MANOVA examining five key performance indicators (cost per intervention, mean response time, preventive action ratios, documentation completeness, and stakeholder feedback incorporation) showed significant performance differences favoring the pilot (Wilks' $\lambda=0.48$, $F(5,24)=5.61$, $p<.001$, partial $\eta^2=0.42$). Although concurrent staff training complicates a purely causal conclusion, the integrated ERP-BPMS appears to be instrumental in these gains.

These findings highlight moderate but significant improvements in proactive decision making, resource alignment, and stakeholder collaboration after unifying risk data, MCDA-based prioritization, and structured engagement within an ERP-BPMS. The following section interprets these results in light of current project management theory and addresses their implications for research and practice.

Discussion. This study investigated whether real-time risk monitoring, structured stakeholder collaboration, and multi-criteria prioritization in a unified ERP-BPMS environment can improve project governance across four contrasting organizations. Case Company A is a utility service provider facing aging infrastructure and frequent repairs. Case Company B is a specialized construction firm handling complex tasks under strict deadlines. Company C is a water technology enterprise that optimizes resource usage using sensor data. Company D is an energy service corporation governed by stringent regulatory demands. Each adopted an approach that combined risk analytics, stakeholder feedback, and adaptive MCDA, aiming to address common challenges, including resource constraints, operational uncertainty, and the need for transparent, data-driven decisions.

Interpretation of Findings. Three main research questions guided this analysis. The first question examined whether real-time risk data and continuous stakeholder engagement boosted operational efficiency and accelerated decision-making. The results showed that response times decreased by approximately 28%, whereas reliability indicators improved by approximately 10-15% across all cases, with some specific metrics showing improvements of up to 16%, as observed in Case D. In Case Company A, the average pipeline repair cycle dropped by approximately 32% following the consolidation of scattered logs and technician reports via the ERP-BPMS, a shift supported by p-values below .001. Although some improvements might reflect concurrent training or stronger managerial focus, cross-context consistency suggests that centralized data visibility and frequent stakeholder input transform reactive processes into more preventive actions [2, 49]. The overall pattern resonates with studies showing that siloed systems hamper early risk detection, whereas unified digital platforms and structured forums encourage real-time collaboration and proactive mitigation.

The second question investigated whether combining continuous data integration and managerial oversight through an MCDA module can refine project prioritization under budget limitations. Each organization applied local parameters to the core model, such as a regulatory urgency factor in Case Company D or a communication complexity metric in Case Company B. Recorded overrides of algorithmic results ranged from about 13-20%, reflecting the constraints of purely algorithmic logic in capturing abrupt fluctuations, such as client-driven design changes or sudden resource shortages. These overrides were documented within the ERP-BPMS, and recurrent patterns prompted iterative fine-tuning of MCDA weights. This hybrid system yielded modest but significant outcomes, such as a ~20% drop in idle equipment in Case B and an uptick in reliability of up to 16% in Case D. Although demonstrating correlation rather than strict causality, these findings support the hypothesis that data-based recommendations anchored by structured expert judgment strengthen resilience in prioritizing resources [18, 50].

The third question focused on whether embedding stakeholder engagement into everyday ERP-BPMS workflows improves cost-effectiveness and satisfaction. The survey data indicated that stakeholder satisfaction increased by roughly 8-12% across all organizations. Between 40 and 70% of the core operational improvements resulted from structured stakeholder inputs captured through the system. For example, Case Company C reorganized approximately 35% of its initial MCDA-ranked projects after partners raised concerns over peak usage periods, which helped reduce follow-up service calls by approximately 29%. Similarly, Company A attributed many of its most successful preventive repairs to monthly community roundtables that offered granular local insights. These findings run counter to the notion that stakeholder forums foster consensus rather than measurable performance gains [3, 11]. Instead, they showed that frequent, digitally integrated engagement can directly inform risk assessment and priority setting, thereby refining operational decisions [12, 22].

Comparison with Existing Literature. These results align with studies on integrated risk scanning and centralized data environments, which report faster responses and stronger coordination in complex multi-stakeholder projects [2, 51]. However, this study extends earlier work by showing that real-time stakeholder input amplifies the positive effects of digital integration, surpassing the gains typically associated with data unification alone [49]. While prior analyses of MCDA emphasize its utility in ranking and scheduling projects [17, 25], this study underscores the importance of adaptive recalibration across sectors, as demonstrated by Case B's parameter workshops and Case D's regulatory multiplier [4]. The interplay of algorithmic scoring with consistent override documentation reflects broader debates on how human oversight complements automated governance [50]. Rather than viewing overrides as failures, these firms treat them as triggers for refining the model to integrate emergent realities.

Moving beyond risk monitoring to stakeholder engagement, earlier stakeholder theory sometimes viewed formal engagement as primarily securing legitimacy or social acceptance [11]. These findings contrast this perspective by demonstrating how

stakeholder dialogues, when linked to digital decision frameworks, can yield tangible cost savings and operational stability. This discrepancy likely stems from the continuous engagement embedded in an ERP-BPMS, which goes beyond one-time consultations. Similar to recent discussions on inclusive project practices, ongoing digital forums allow localized knowledge to shape daily task prioritization [10, 22]. The net effect is a model in which agile feedback loops connect local intelligence with algorithmic evaluations, enhancing the relevance of decisions while reinforcing stakeholder trust [9].

Theoretical Contributions. This study advances several theoretical perspectives on this topic. First, it illustrates how dynamic capabilities—sensing, seizing, and reconfiguring—occur within day-to-day project routines through an integrated digital platform [27, 28]. Real-time risk alerts and stakeholder inputs constitute the sensing arm, data-driven MCDA guides the seizing of crucial tasks, and the iterative override process enables reconfiguration in response to overlooked risks or shifting priorities. The explicit tracking of override rationales shows how knowledge from unanticipated events is systematically incorporated into refined scoring criteria, bridging strategic-level capabilities with on-the-ground project management.

While dynamic capabilities explain the organizational mechanisms at play, the second theoretical contribution enriches stakeholder theory by empirically demonstrating the instrumental benefits of sustained engagement. Rather than operating only at an ethical or relational level, continuous stakeholder dialogue improves the costs, reliability, and user satisfaction. This aligns with [52] findings regarding the crucial role of governmental stakeholder engagement in achieving sustainability outcomes in industrial engineering projects. Case C’s recalibrations based on partner feedback provided an instructive example of local knowledge shaping real-world improvements. This aligns with research linking stakeholder collaboration to tangible project outcomes, but highlights how digital workflows serve as key facilitators [29, 53].

Third, this research refines project portfolio management theory by showing that a knapsack-style MCDA can thrive in diverse sectors if supplemented by localized customizations and feedback loops [4]. This extends the work [54], who demonstrated the effectiveness of roadmap optimization for multi-annual project portfolio selection by showing how dynamic recalibration of parameters can enhance long-term planning outcomes. The findings from Cases B and D underscore that domain-specific variables, whether regulatory pressure or communication complexity, must be integrated for robust prioritization. This speaks to the literature on adaptive portfolio selection methods that favor iterative learning over static scoring formulas [16].

Fourth, the study clarifies balanced governance in digital project environments [55]. Override rates of 13-20% imply that purely algorithmic decisions omit the key context. Documented overrides, rather than undermining the system, improved it by incorporating emergent factors, contributing to a more nuanced understanding of how human insights and automated analysis coalesce [2]. This synergy stands apart from polarized views of either complete automation or managerial dominance, illustrating that carefully documented exceptions can catalyze model enhancements [50].

Fifth, it highlights the centrality of data quality in realizing the benefits of enterprise platforms. Initial inconsistencies in 25-40% of the data were addressed through cleansing. This improvement indicates that even a sophisticated ERP-BPMS equipped with advanced modules remains limited if it lacks reliable, consistent inputs [20, 49, 56]. The observed performance shifts after data remediation confirm that the robust governance of information underpins the integrated framework.

Practical Implications. Several practical recommendations have emerged based on these insights. First, organizations considering advanced analytics should unify operational, financial, and stakeholder data within a single ERP-BPMS before implementing complex prioritization methods. Fragmented data hinders the timely detection of risk signals, as demonstrated by Case Company C, which saw a considerable drop in delayed interventions once it integrated multiple databases [35]. Second, the MCDA frameworks require iterative recalibration. This is particularly

relevant for managing external stakeholder risks, where [57] demonstrated that response strategy selection in project portfolios requires systematic recalibration over the project life cycle to maintain alignment with evolving stakeholder concerns and organizational priorities. Routine parameter reviews, such as those in Case B, can reduce override rates and preserve the alignment between scores and real-world conditions. These sessions can include domain experts, data analysts, and stakeholder representatives to examine inconsistent or unexpected prioritization results.

A third implication is that managerial overrides are not system failures, but learning opportunities. Each override offers a lens for unmodeled variables or new operational complexities. Systematic logging of these decisions within the ERP-BPMS can guide incremental improvements in the MCDA model, thus maintaining its relevance in dynamic settings [30]. Fourth, institutionalizing stakeholder forums—monthly or bi-weekly—directly within the digital workflow can capture localized knowledge, forestall unplanned disruptions, and nurture the acceptance of algorithmic outputs [22, 58]. Participants were more likely to share candid feedback if they saw it as meaningfully shaping risk assessments and task rankings.

Data quality initiatives represent the fifth priority. Each firm addressed initial rates of 25-40% data inconsistencies through structured "data integrity" campaigns, with outcomes such as significant improvements in system reliability within a year [59]. These efforts include staff training for accurate data entry, standardized documentation protocols, and continuous audits for anomalies. Sixth, confidentiality measures must be explicit to reassure users that sensitive inputs such as project costs or community concerns are protected. Credible security practices, including role-based access and encryption, help preserve trust and sustain open engagement [46]. Without this trust, stakeholder collaboration that underpins much of the observed value can be eroded.

Limitations. Several constraints limit the generalizability of these findings. The project spanned six to 18 months of ERP-BPMS use in each organization, which may not capture long-term sustainability, seasonal fluctuations, or leadership changes over

multiple years. Next, each participating firm demonstrated moderate to high digital readiness and strong management support, conditions that might not translate into less digitally advanced or less committed environments. The quasi-experimental elements in Case Company A do not fully eliminate confounding factors, including market shifts or parallel improvement programs. Standardized performance metrics, while enabling cross-case comparisons, may have missed nuances unique to each firm's processes or stakeholders. Lastly, the voluntary nature of participation suggests a potential self-selection bias, with innovation-friendly organizations more inclined to adopt and benefit from digital transformation.

Future Research. These limitations open several avenues for future research. Longitudinal studies tracking three to five years of system use would reveal whether early improvements endure or require repeated recalibration to address emergent project demands [4]. Investigations in lower-maturity contexts could assess which fundamental conditions, such as a baseline of consistent data capture or committed local leadership, are most critical for successful ERP-BPMS adoption [17]. Cross-cultural research may also explore how override patterns vary by power distance or other sociocultural factors, potentially revealing whether local norms influence the acceptance of algorithmic recommendations [60]. Tests of advanced machine learning approaches for predictive risk detection could further refine the MCDA engine, but would need to address transparency and stakeholder trust challenges [2]. Future investigations could also compare monthly and continuous stakeholder feedback loops, clarifying how engagement frequency and format affect outcomes in different industries [22, 61]. Finally, adding environmental and social responsibility metrics to the MCDA may align the framework more closely with emerging sustainability standards, extending its relevance to the broader aims of stakeholder-centered project management [29]. Such inquiries would build on the current evidence that an integrated ERP-BPMS, enriched by real-time stakeholder input and adaptive prioritization, can deliver measurable improvements in project governance and resource stewardship.

Conclusions. This study reveals that unifying real-time risk monitoring, structured stakeholder engagement, and multi-criteria prioritization within an ERP-BPMS environment can significantly strengthen project governance in diverse operational settings. Four anonymized organizations from diverse geographic regions—Case Company A (a utility provider in Eastern Europe), Case Company B (a specialized construction firm in Central Europe), Case Company C (a water-technology enterprise in North America), and Case Company D (an energy service provider in the Middle East)—transitioned from fragmented, reactive methods to more proactive and data-informed approaches. Response times improved by approximately 25–35%, preventive actions rose by 14–23 percentage points (p.p.), and stakeholder satisfaction increased by approximately 8–12%, reflecting how systematic data consolidation and transparent decision routines can deliver sustained operational benefits [9, 11, 29].

These findings address the following three core questions: First, blending real-time risk alerts with stakeholder inputs enhances operational effectiveness by enabling early problem detection and swifter resource allocation [2]. Managers shifted from crisis responses to preventive actions, confirming that the constant visibility of risk signals, backed by open communication channels, drives greater efficiency. Second, continuous data integration and a multi-criteria decision framework support cost-effectiveness under budget constraints [4]. Although algorithmic prioritization guided most routine decisions, approximately 12–20% were overridden by managers who leveraged contextual insights that were not fully captured by automated scoring, echoing calls for balanced governance between technology and expert judgment [18, 50]. Third, embedding regular stakeholder engagement into everyday digital workflows improves satisfaction by giving local perspectives real weight in priority settings [12, 62].

From a theoretical standpoint, the study extends dynamic capabilities theory by illustrating how sensing (risk detection), seizing (structured prioritization), and reconfiguring (stakeholder-informed adaptation) operate in an integrated digital

infrastructure [27, 28]. It also enriches stakeholder theory by demonstrating that ongoing digitally mediated collaboration yields tangible improvements in resource allocation and stakeholder well-being, rather than functioning solely as a normative ideal [11, 29]. Practically, managers can replicate this synergy by scheduling periodic calibration sessions to refine decision parameters, using transparent logging of risk events and stakeholder interactions in the ERP-BPMS and convening regular roundtables to address emergent challenges. While these four organizations showed moderate to high digital readiness, the essential principles—holistic data streams, open communication, and adaptive project selection—can be applied in less technologically mature environments, given appropriate tailoring.

This study had several limitations must be recognized. The six-to eighteen-month observation windows did not capture long-term or cyclical patterns, and focusing on firms already inclined toward digital transformation may limit broader generalizability. Future research could examine the evolution of such governance methods over multi-year horizons, explore their viability in more resource-constrained contexts, or integrate advanced analytics (e.g., AI-driven risk detection) while preserving transparency for stakeholders. Cross-cultural comparisons might reveal how institutional and local expectations shape the relative roles of algorithmic outputs versus managerial discretion in project prioritization.

In summary, this multi-case analysis confirms that a cohesive blend of real-time risk assessment, stakeholder-centered engagement, and adaptive prioritization substantially enhances project governance across different sectors. By consolidating these elements within an ERP-BPMS, organizations can detect issues sooner, allocate resources more effectively, and foster deeper trust among diverse participants. These insights add to ongoing discussions on dynamic capabilities, stakeholder theory, and sustainable project management, while offering a practical roadmap for managers seeking a data-driven, participatory, and future-oriented approach to complex initiatives.

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