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Enhancing Decision-Making in Technical Economics Through ERP-Based Data Analytics

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ABSTRACT

The integration of Enterprise Resource Planning (ERP) systems with data analytics has transformed decision-making processes within the field of technical economics. This study examines how ERP-based data analytics can enhance the accuracy, efficiency, and strategic quality of economic decisions in engineering and industrial environments. By combining real-time data collection, process automation, and predictive modeling, ERP platforms enable organizations to identify cost-saving opportunities, optimize resource allocation, and improve overall operational performance. The research employs a mixed-method approach, incorporating quantitative data from industrial case studies and qualitative insights from managerial interviews. The findings indicate that ERP-driven analytics significantly reduce decision latency, improve forecasting precision, and strengthen cross-departmental coordination. This paper concludes that integrating ERP-based data analytics into technical economic management fosters more adaptive, data-driven decision-making frameworks essential for sustainable industrial competitiveness.

1. Introduction

In the current landscape of global industrial transformation, the intersection between engineering and economics has become increasingly significant in shaping sustainable business performance (Davenport et al., 2010). Technical economics, which bridges engineering principles with economic evaluation, provides a systematic framework for analyzing efficiency, productivity, and cost-effectiveness in industrial operations (Shang & Seddon, 2002). As industries become more data-intensive and interconnected, the need for effective decision-making tools that can integrate complex technical and financial data has grown exponentially (Laudon & Laudon, 2004). In this context, Enterprise Resource Planning (ERP) systems have emerged as a central technological infrastructure that enables organizations to streamline processes, improve information visibility, and enhance strategic coordination across departments (Wagner & Monk, 2011).

Originally developed to integrate core business functions such as finance, production, logistics, and human resources, ERP systems have evolved beyond transactional management into advanced analytical platforms (O'Leary, 2000). The incorporation of data analytics capabilities within ERP systems allows organizations to transform raw data into actionable insights, thereby strengthening their decision-making capacity (Davenport et al., 2010). This convergence of ERP and data analytics represents a crucial step in digital transformation, providing managers and engineers with real-time access to performance metrics, predictive forecasts, and optimization models that directly inform economic and technical decisions (Hitt et al., 2002).

In technical economics, decision-making involves evaluating multiple variables—such as cost, efficiency, material utilization, production capacity, and risk—under dynamic market and operational conditions (Simon, 1960). Traditional decision-making approaches, often based on fragmented data and manual calculations, are no longer sufficient to handle the scale and complexity of modern industrial systems (Beheshti, 2006). ERP-based data analytics addresses these limitations by enabling integrated data collection, multidimensional analysis, and evidence-based decision support. Through predictive analytics and machine learning integration, ERP platforms can anticipate cost fluctuations, project performance deviations, and maintenance requirements, ultimately leading to more informed and proactive managerial decisions (Ngai et al., 2011).

Moreover, the integration of ERP-based analytics contributes to strategic alignment between engineering and economic objectives. For instance, in manufacturing sectors, ERP systems enable the synchronization of production schedules with market demand forecasts, optimizing both resource utilization and financial outcomes. In project-based industries such as construction and energy, ERP analytics assist in cost estimation, investment appraisal, and lifecycle analysis, ensuring that technical decisions remain economically sound and strategically viable (Moon, 2007). Such capabilities not only enhance operational efficiency but also foster long-term competitiveness and innovation (Turban, 2011).

However, despite the recognized benefits of ERP systems, many organizations still face substantial barriers in realizing their full analytical potential (Aloini et al., 2007). These challenges include data fragmentation across departments, inadequate data governance, lack of user training, and the high cost of system customization (Sarker & Lee, 2003). In particular, small and medium-sized enterprises (SMEs) often struggle to integrate ERP analytics due to limited technical expertise and financial resources (Motiwalla & Thompson, 2012). Consequently, there remains a gap between the theoretical potential of ERP-based decision-making and its practical implementation in real-world industrial settings.

This research seeks to bridge that gap by examining how ERP-based data analytics can enhance decision-

making in technical economics (Shang & Seddon, 2002). The study investigates the extent to which ERP analytics improve the accuracy, speed, and consistency of economic decisions in engineering-related operations. It also explores the role of predictive modeling, data integration, and visualization tools in supporting managerial judgment and strategic planning (Al-Mashari et al., 2003). Through a mixed-method approach—combining quantitative analysis of industrial performance data with qualitative insights from practitioners—this paper aims to provide a comprehensive understanding of the economic and operational impacts of ERP-driven analytics (Davenport et al., 2010).

Ultimately, this study contributes to the academic discourse on digital transformation and industrial management by offering new perspectives on the integration of ERP and data analytics within the domain of technical economics. By identifying best practices and potential pitfalls, it provides a foundation for both researchers and practitioners to develop data-driven frameworks that align technological innovation with economic sustainability. In a rapidly evolving industrial environment where information is the key asset, ERP-based data analytics emerges not merely as a tool but as a strategic enabler of intelligent, adaptive, and economically sound decision-making (Wagner & Monk, 2011).

2. Methodology

Research Design

This study adopts a mixed-method research design that combines both quantitative and qualitative approaches to provide a comprehensive understanding of how ERP-based data analytics enhance decision-making within the domain of technical economics (Hitt et al., 2002). The mixed-method framework allows for triangulation between statistical data analysis and experiential insights, ensuring both empirical robustness and contextual depth (Davenport et al., 2010). The quantitative component evaluates measurable outcomes such as efficiency improvements, cost reductions, and decision accuracy derived from ERP implementation (Shang & Seddon, 2002). Meanwhile, the qualitative component explores managerial experiences, perceptions, and challenges through semi-structured interviews with key decision-makers in technical and industrial sectors (O'Leary, 2000).

The research follows a sequential explanatory design, where quantitative data collection and analysis are conducted first to identify significant patterns and relationships. The qualitative phase then follows, providing interpretative explanations for the observed statistical results. This approach ensures that numerical findings are contextualized within organizational realities, particularly in how ERP analytics are used to support technical and economic decision-making processes.

Population and Sample

The population of this study consists of engineering-based manufacturing and industrial firms that have adopted ERP systems integrated with data analytics modules (Aloini et al., 2007). These firms operate in sectors such as automotive manufacturing, construction engineering, energy production, and industrial equipment fabrication. From this population, a purposive sampling technique was used to select 30 firms that have implemented ERP solutions for at least three years. This criterion ensures that participants have adequate experience and historical data relevant to evaluating ERP effectiveness (Wagner & Monk, 2011).

Within these firms, two categories of participants were identified:

1. Technical professionals — including engineers, production planners, and project managers who directly engage with ERP-generated data in operational decision-making.

2. Economic and managerial staff — such as financial analysts, operations managers, and

executives responsible for evaluating project feasibility, budgeting, and resource allocation.

In total, 120 respondents participated in the quantitative survey, while 20 participants were selected for qualitative interviews to provide detailed insights into ERP usage and decision-making practices (Laudon & Laudon, 2004).

Data Collection Methods

Data collection was carried out through three primary methods:

No	Data Collection Method	Description	Purpose / Focus of Analysis
1	Structured Survey Questionnaires	A structured questionnaire was electronically distributed to selected firms. The questionnaire consisted of 35 items using a five-point Likert scale to measure respondents' perceptions of ERP system performance, decision-making efficiency, data accuracy, and departmental integration.	To measure respondents' perceptions of ERP performance, ERP-based analytics in cost control, forecasting, and process optimization.
2	In-Depth Interviews	Semi-structured interviews were conducted with 20 managerial-level respondents to explore qualitative dimensions of ERP analytics usage. Each interview lasted between 45 and 60 minutes and was transcribed verbatim for thematic analysis.	To explore challenges in system adoption, data interpretation practices, decision-making dynamics, and perceived organizational benefits.
3	Secondary Data Review	Organizational reports and ERP system logs were reviewed to complement primary data. These documents included monthly performance summaries, ERP dashboards, and financial reports related to production efficiency and cost management.	To provide empirical evidence of how ERP analytics influence key performance indicators (KPIs) in real operational contexts.

Research Instruments and Variables

The main research instrument—the questionnaire—was developed based on validated frameworks from prior ERP and data analytics studies. Key variables include:

- Independent Variable: ERP-based data analytics utilization (measured through system integration level, data quality, and analytical functionality).
- Dependent Variable: Decision-making effectiveness in technical economics (measured through timeliness, accuracy, cost efficiency, and risk management quality).
- Control Variables: Firm size, industry type, and ERP vendor to account for contextual differences.

Reliability testing using Cronbach's Alpha yielded a coefficient of 0.91, indicating high internal consistency. Validity testing was conducted through factor analysis, confirming that each construct reliably represented its intended dimension.

Data Analysis Techniques

Quantitative data were analyzed using Statistical Package for the Social Sciences (SPSS) and Structural Equation Modeling (SEM) via AMOS software to identify causal relationships between ERP analytics usage and decision-making performance (Shang & Seddon, 2002). Descriptive statistics summarized central tendencies, while regression analysis tested the strength of influence between variables (Wagner & Monk, 2011).

For the qualitative data, thematic analysis was applied following Braun and Clarke's methodology (Braun & Clarke, 2006). Interview transcripts were coded inductively to identify recurring themes such as "data-driven decision culture," "predictive analytics in planning," and "integration challenges." Triangulation between quantitative and qualitative findings was employed to validate results and

enhance the reliability of interpretations (Turban, 2011).

Ethical Considerations

All participants were informed about the purpose and confidentiality of the research before data collection. Participation was voluntary, and no personal identifiers were included in published results. Ethical approval was obtained from the institutional research board, ensuring compliance with academic integrity and professional ethical standards (Motiwalla & Thompson, 2012).

Materials and Tools

The study utilized various technological and analytical materials to support data collection and processing. ERP systems used by participating firms included SAP S/4HANA, Oracle ERP Cloud, and Microsoft Dynamics 365, each offering advanced analytical dashboards and data visualization tools. Analytical operations were supported by Python and R Studio for data cleaning and preliminary statistical tests (Ngai et al., 2011). Visualization of findings was conducted through Tableau, enhancing interpretability for both technical and non-technical audiences (Davenport et al., 2010).

In summary, the methodology ensures a comprehensive exploration of how ERP-based data analytics influence decision-making in technical economics. By combining quantitative rigor with qualitative depth, the research design captures not only the measurable impacts of ERP integration but also the contextual nuances of managerial judgment and organizational adaptation in data-driven industrial environments (Huang & Benyoucef, 2013).

3. Result and Discussion

The quantitative analysis revealed a strong and statistically significant relationship between the utilization of ERP-based data analytics and the improvement of decision-making effectiveness in technical economics. Using Structural Equation Modeling (SEM), the path coefficient between ERP analytics and decision-making performance was found to be 0.78 ($p < 0.001$), indicating a high level of influence (Shang & Seddon, 2002). This demonstrates that firms employing integrated ERP analytics exhibit superior decision-making capabilities compared to those relying solely on traditional data systems.

Descriptive statistics further showed that 82% of respondents agreed that ERP analytics improved the accuracy and timeliness of their economic evaluations, while 76% reported enhanced efficiency in project planning and resource allocation. Moreover, 69% of participants noted a significant reduction in decision latency—defined as the time required to translate data into actionable business decisions—after ERP integration (Davenport et al., 2010).

Regression analysis indicated that among the various ERP analytical components, predictive modeling and dashboard visualization contributed most significantly to decision-making quality. Predictive analytics enabled firms to forecast cost trends, material demand, and machine utilization rates with higher accuracy, while dashboards facilitated real-time monitoring and rapid decision adjustments (Davenport et al., 2010). These results align with previous findings by Lee et al., who emphasized the role of ERP analytics in bridging technical data with economic interpretation through interactive visualization tools.

Additionally, firms with longer ERP adoption periods (above five years) demonstrated higher decision-making maturity levels, suggesting a learning curve effect where continued use of ERP systems fosters analytical competence and strategic insight (Laudon & Laudon, 2004). Larger firms also tended to achieve greater benefits due to stronger financial and technical resources, enabling better system customization and user training (Wagner & Monk, 2011).

Qualitative Findings

The qualitative phase of the study provided deeper insights into how ERP analytics reshape managerial behavior and decision-making culture. Through thematic analysis, four dominant themes emerged:

1. Data-Driven Decision Culture

Many participants emphasized that ERP analytics had instilled a stronger culture of evidence-based decision-making. Managers and engineers increasingly relied on real-time performance metrics rather than intuition or experience alone. One production manager noted, "Before ERP analytics, we often made budget or scheduling decisions based on last year's outcomes. Now, with predictive dashboards, we make decisions supported by accurate projections and real-time data."

This shift marks a cultural transformation in how organizations interpret and act upon economic and technical information. It reflects the growing role of digital literacy and analytical thinking as core competencies in modern engineering management.

2. Integration of Technical and Financial Insights

The second theme highlighted how ERP analytics serve as a bridge between engineering and finance departments. The integration of technical indicators—such as production output, energy consumption, and maintenance cycles—with financial data like cost per unit and ROI (Return on Investment) has enabled holistic decision-making. For example, when analyzing equipment upgrades, firms could now simulate both technical feasibility and economic impact simultaneously, leading to more strategic investments.

This finding supports the theoretical model of Integrated Decision Frameworks, where the convergence of operational and financial data produces optimized economic outcomes (Koh et al., 2020).

3. Predictive and Preventive Management

The use of predictive analytics within ERP systems emerged as a transformative factor in technical economics. Respondents described how predictive models helped anticipate cost overruns, equipment failures, and supply chain disruptions. One engineer from an energy firm explained, "We use ERP predictive modules to forecast maintenance needs, preventing costly downtime. This directly impacts our operational economics and risk control."

The results demonstrate that ERP analytics not only enhance current decision-making but also facilitate preventive economic management, where decisions are made proactively based on data-driven foresight rather than reactive responses to problems.

4. Challenges and Adaptation Barriers

Despite the benefits, several organizations still encountered barriers related to system complexity, lack of analytical skills, and data governance. In particular, smaller firms struggled to interpret analytical outputs due to limited expertise in data science. Some respondents admitted that although ERP systems produced abundant data, managers were often uncertain how to translate it into actionable insights. These challenges underline the importance of continuous training, cross-functional collaboration, and leadership commitment in fully realizing the potential of ERP-based analytics.

Integration of Findings

When combining both quantitative and qualitative results, the study clearly demonstrates that ERP-based data analytics significantly enhance decision-making within the scope of technical economics. Quantitative evidence confirms measurable improvements in decision accuracy, cost efficiency, and timeliness, while qualitative insights reveal cultural and organizational transformations that enable data-driven operations.

The findings suggest that ERP analytics function as both a technological enabler and a managerial catalyst. Technologically, ERP integrates scattered

data sources into coherent analytical frameworks, improving visibility and control across engineering and financial processes. Managerially, it promotes transparency, accountability, and informed reasoning, reducing the likelihood of subjective or uninformed decisions.

These outcomes reinforce the Decision Support Theory (Simon, 1977), which posits that effective decision-making relies on structured, accurate, and timely information. ERP-based analytics embody this principle by converting raw operational data into structured knowledge that supports both routine and strategic decisions in engineering-based economies.

Furthermore, the study found that firms utilizing ERP predictive analytics achieved an average of 14% cost reduction and 11% improvement in production efficiency compared to baseline levels before ERP adoption. These improvements are attributed to optimized resource allocation, real-time monitoring, and reduced error margins in project cost estimation.

The integration between ERP and data analytics also aligns with the concept of Technical-Economic Synergy, where technological systems and economic analysis reinforce each other in achieving organizational efficiency. ERP-based analytics not only provide data but also contextualize it within economic frameworks, enabling firms to quantify the financial consequences of technical decisions—such as material substitution, machinery upgrades, or workflow redesigns.

Discussion and Analysis

The results of this research contribute to the broader understanding of digital transformation in industrial management. ERP-based data analytics emerge as a strategic asset for organizations seeking to enhance decision quality in environments characterized by complexity, uncertainty, and rapid technological change.

From a theoretical perspective, the findings extend the discourse on Digital Decision-Making Models by demonstrating how ERP systems operationalize data-driven logic within technical economics. Unlike traditional ERP systems focused solely on process automation, the integration of analytics enables dynamic learning, predictive insight, and adaptive management—features essential for competitiveness in Industry 4.0 contexts.

From a practical standpoint, organizations should view ERP analytics not merely as software but as a strategic framework for knowledge integration. Successful adoption requires not only technological investment but also human capability development, organizational restructuring, and continuous improvement in data governance. The human factor—particularly analytical literacy among managers and engineers—plays a decisive role in maximizing the value of ERP data outputs.

Ultimately, the study demonstrates that ERP-based data analytics bridge the long-standing gap between engineering precision and economic reasoning. They enable firms to operate intelligently, respond proactively to environmental changes, and sustain economic efficiency through informed, evidence-based decisions.

4. Conclusion

This study provides comprehensive evidence that the integration of Enterprise Resource Planning (ERP) systems with data analytics significantly enhances decision-making processes within the field of technical economics. Through the combination of quantitative and qualitative analyses, the research demonstrates that ERP-based analytics not only improve the accuracy, timeliness, and efficiency of decisions but also transform organizational culture toward a more data-driven and strategic orientation.

From a quantitative standpoint, statistical analysis confirmed a strong positive correlation between the level of ERP analytics utilization and the quality of economic decision-making. Firms with mature ERP systems and advanced analytical modules consistently reported better performance in areas such as project cost estimation, production planning,

and financial forecasting. The use of predictive analytics and real-time dashboards was found to be particularly influential, allowing organizations to anticipate cost fluctuations, optimize resources, and reduce operational inefficiencies.

Qualitatively, the study revealed that ERP-based analytics reshape the managerial mindset by promoting transparency, accountability, and data literacy across departments. Decision-making in technical economics has evolved from being experience-based to becoming evidence-based, where managerial actions are guided by verified, real-time data rather than subjective interpretation. This shift reflects a broader transformation within industrial organizations toward digital maturity and analytical sophistication.

Moreover, the integration of ERP and analytics fosters cross-functional collaboration between engineering, finance, and operations. Technical decisions—such as machinery upgrades, production scheduling, or material selection—are now evaluated not only in terms of technical feasibility but also in terms of economic impact and sustainability. This holistic approach strengthens the alignment between operational efficiency and financial performance, creating a synergistic relationship between technology and economics.

Another key finding is the role of predictive analytics in supporting proactive and preventive management. ERP systems enable firms to forecast potential risks such as equipment downtime, supply chain disruptions, and cost overruns before they occur. This capability contributes to the development of adaptive and resilient organizations capable of responding effectively to market and operational uncertainties. As a result, ERP-based analytics emerge as a cornerstone of modern technical-economic intelligence, where decision-making is dynamic, integrated, and forward-looking.

However, the research also acknowledges existing challenges in implementing ERP analytics effectively. Smaller firms, in particular, face barriers related to system complexity, financial limitations, and the shortage of analytical skills. Even in larger enterprises, the absence of continuous training, inconsistent data governance, and resistance to organizational change often hinder the full realization of ERP's potential. Therefore, technological advancement must be accompanied by human capital development and institutional adaptation to achieve sustainable analytical capability.

In summary, the findings reinforce that ERP-based data analytics serve as both a technological enabler and a strategic instrument for enhancing decision-making in technical economics. They provide the informational foundation necessary for engineering-based industries to pursue efficiency, competitiveness, and innovation in an increasingly data-centric global economy.

Recommendations

Based on the results and interpretations of this research, several recommendations are proposed for both practitioners and future researchers in the field of technical economics and ERP management.

Strengthen Analytical Competence and Training Programs

Organizations should invest in continuous training programs to improve analytical literacy among engineers, managers, and decision-makers. The effectiveness of ERP-based analytics depends not only on system capabilities but also on the ability of users to interpret data, identify patterns, and make informed judgments. Integrating analytical training into technical and managerial education can enhance decision quality and organizational adaptability.

Promote Cross-Departmental Data Integration

ERP systems achieve their full potential when data flows seamlessly across departments. Firms should eliminate data silos and encourage real-time collaboration between engineering, finance, and operations. This approach ensures that decisions are based on comprehensive and synchronized information, reflecting both technical and economic perspectives.

Adopt Predictive and Prescriptive Analytical Models

Beyond descriptive analytics, organizations should advance toward predictive and prescriptive models to forecast future outcomes and recommend optimal actions. Predictive models allow firms to anticipate risks, while prescriptive analytics can guide decision-makers toward the most efficient solutions. This evolution will further strengthen the precision and strategic value of ERP-driven insights.

Ensure Strong Data Governance and Quality Assurance

Reliable decision-making requires accurate and consistent data. Companies should establish clear data governance policies that define ownership, validation, and security protocols. High-quality data enhances the trustworthiness of analytical outputs and minimizes errors that could undermine economic assessments.

Customize ERP Analytics to Fit Organizational Context

Each organization operates under unique technical, financial, and cultural conditions. Therefore, ERP systems and their analytical modules should be tailored to align with specific operational needs and industry requirements. Customization ensures that ERP analytics deliver relevant insights and actionable intelligence for particular economic scenarios.

Encourage Research Collaboration Between Academia and Industry

Academic institutions and industrial organizations should collaborate to develop context-specific ERP analytical models suitable for local economic and technological environments. Collaborative research can generate practical solutions and empirical evidence that strengthen both theoretical development and industrial application in technical economics.

Future Research Directions

Future studies may expand this research by examining sector-specific differences in ERP analytics implementation, such as comparing manufacturing, energy, and construction industries. Researchers could also employ longitudinal approaches to assess how ERP analytics maturity evolves over time and its long-term effects on economic performance and decision-making sustainability.

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