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# Decision Intelligence: The New Core of Industrial Management in Complex and Uncertain Environments

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## Introduction

Industrial management is entering a period in which uncertainty has become the defining characteristic of organizational decision-making rather than an occasional exception. As environmental complexity and dynamism intensify, competitive advantage is no longer determined solely by operational efficiency but by an organization's capability to sense changes, interpret uncertainty, and respond intelligently before disruptions escalate. In this context, decision-making itself has emerged as a strategic organizational capability rather than merely an operational function. As Vecchiato (2012) argues, strategic foresight should no longer be viewed as an exercise in predicting the future with certainty but as a continuous learning process that enables organizations to detect emerging opportunities and threats and respond more effectively. Likewise, Nobari et al. (2022) emphasize that organizations facing uncertain environments require new forms of intelligence capable of transforming dispersed information into actionable knowledge, allowing managers to move beyond prediction toward adaptive and resilient decision processes.

The growing complexity of industrial environments has consequently transformed the role of decision support systems from simple computational tools into intelligent cognitive infrastructures. Earlier generations of Decision Support Systems (DSS) primarily focused on structured optimization problems using deterministic mathematical models. However, modern industrial environments require decision architectures capable of processing heterogeneous data, learning from dynamic environments, integrating expert knowledge, and continuously adapting to unforeseen events. The convergence of Operations Research (OR), Artificial Intelligence (AI), machine learning, Internet of Things (IoT), digital twins, and advanced analytics has significantly

expanded the capabilities of contemporary decision support systems. Rather than simply recommending optimal solutions, intelligent decision systems are increasingly expected to evaluate multiple scenarios, quantify uncertainty, explain recommendations, and support collaborative human judgment. Subrahmanyam and Beainy (2027) argue that modern DSS has evolved into an intelligent ecosystem integrating AI, stochastic modeling, fuzzy reasoning, and Industry 4.0 technologies to improve organizational resilience under disruption. Similarly, Marques et al. (2017) demonstrate that decentralized decision support has become indispensable in smart manufacturing environments, where decisions must be distributed across strategic, tactical, operational, and real-time levels to accommodate the complexity of Industry 4.0 production systems.

This evolution has given rise to the emerging paradigm of Decision Intelligence (DI), a concept that extends far beyond conventional business analytics or artificial intelligence. Decision Intelligence represents an interdisciplinary framework that combines data science, operations research, behavioral sciences, systems thinking, and artificial intelligence to improve the quality, transparency, and adaptability of managerial decisions. Unlike traditional analytical approaches that primarily focus on prediction, Decision Intelligence emphasizes the complete decision lifecycle—from sensing environmental signals and generating alternatives to evaluating consequences, learning from outcomes, and continuously improving organizational knowledge. Gupta et al. (2022) highlight that the integration of AI with Operations Research fundamentally changes the role of decision support by introducing learning capabilities, predictive intelligence, and adaptive optimization into managerial processes. Likewise, Chan and Ding (2023) argue that industrial intelligence is reshaping production and operations management by embedding machine learning, industrial AI, and intelligent analytics into operational decision-making, enabling organizations to move from reactive management toward proactive and autonomous decision systems. Consequently, industrial intelligence is no longer measured by the amount of available data but by the organization's ability to transform information into consistently superior decisions.

Another defining characteristic of Decision Intelligence is its capacity to manage uncertainty rather than eliminate it. Contemporary industrial systems rarely operate under conditions where complete information or deterministic assumptions exist. Instead, managers increasingly rely on probabilistic reasoning, fuzzy logic, Bayesian inference, simulation, and hybrid AI models to evaluate competing alternatives under ambiguous conditions. These approaches recognize that uncertainty is inherent in industrial systems and therefore should be incorporated into decision architectures rather than treated as a modeling limitation. Martínez-Vivar et al. (2026), for example, propose a fuzzy logic–based theoretical framework that enhances transparency, robustness, and scalability by integrating contextual variables, expert judgment, and explainable inference mechanisms into organizational decision systems. Mohanty et al. (2025) similarly identify fuzzy logic as one of the most effective foundations for industrial intelligence because of its ability to

accommodate ambiguity while supporting intelligent automation. Recent developments further extend these capabilities through Bayesian learning and neuromorphic intelligence. Tasleem et al. (2026) demonstrate how Bayesian machine learning enables uncertainty-aware strategic investment decisions by explicitly incorporating probabilistic reasoning into managerial decision processes, while Nozari (2026) illustrates how neuromorphic computing integrated with fuzzy multi-objective optimization significantly improves adaptive decision-making within resilient and environmentally sustainable supply chains.

## Insights from This Issue

The articles featured in this issue collectively demonstrate that industrial management is increasingly evolving into a discipline centered on intelligent decision-making under complexity and uncertainty. Although the studies address diverse industrial contexts, including energy systems, humanitarian logistics, manufacturing, digital platforms, supply chain management, and enterprise governance, they share a common methodological orientation: supporting managers in making better decisions through advanced analytical models. Rather than treating optimization as an isolated mathematical exercise, these contributions emphasize decision quality as the ultimate objective of industrial analytics. Whether through multi-stage efficiency assessment, stochastic optimization, simulation, or risk evaluation, the studies reveal a clear transition from descriptive analyses toward prescriptive and decision-oriented management approaches. Together, they reinforce the notion that the future of industrial competitiveness depends not merely on collecting more data but on developing intelligent mechanisms capable of converting data into timely, transparent, and actionable decisions. A second notable insight concerns the growing integration of multiple analytical paradigms to address increasingly complex industrial problems. Traditional single-method approaches are gradually being replaced by hybrid decision frameworks that combine optimization, simulation, multicriteria decision-making, fuzzy logic, network analysis, and risk assessment. For instance, the application of multi-stage DEA integrated with PROMETHEE II for evaluating global retail firms illustrates how efficiency measurement can be strengthened through preference-based decision models. Similarly, studies on supplier selection, location-routing, humanitarian logistics, and scheduling employ sophisticated optimization techniques to reconcile conflicting operational objectives while accounting for practical constraints and uncertainty. These methodological developments reflect an important evolution within industrial management, where the emphasis is shifting from identifying a mathematically optimal solution to supporting robust managerial decisions that remain effective under changing environmental conditions.

Another important contribution of this issue lies in its strong emphasis on uncertainty, resilience, and risk governance as central dimensions of managerial decision-making. Several articles explicitly recognize that industrial systems now operate in environments characterized by

volatility rather than stability. Research addressing enterprise risk management, reliability-based maintenance scheduling in gas infrastructure, and humanitarian logistics demonstrates that managing uncertainty has become an integral component of operational excellence. Likewise, investigations into cybersecurity risks in digital platforms and service quality within online sales environments highlight that digital transformation introduces not only new opportunities but also new categories of strategic and operational risks. Collectively, these studies suggest that future industrial organizations must develop decision architectures capable of anticipating disruptions, evaluating multiple scenarios, and dynamically adapting strategies as new information becomes available. Such capabilities represent essential building blocks of Decision Intelligence and distinguish contemporary industrial management from its traditionally optimization-driven foundations. Finally, this issue illustrates that intelligent decision-making is increasingly extending beyond operational efficiency toward broader organizational and societal objectives. Several contributions incorporate sustainability, environmental performance, customer value, innovation, and long-term competitiveness into their analytical frameworks. Research on green efficiency in petrochemical supply chains, factory less manufacturing strategies, and digital service quality demonstrates that managerial decisions are no longer evaluated solely through economic performance indicators but also through their environmental, technological, and stakeholder impacts. This broader perspective reflects the growing maturity of industrial management as a discipline, where decision quality is defined not only by optimal resource allocation but also by the ability to balance efficiency, resilience, sustainability, and strategic value creation. Viewed collectively, the articles in this issue portray Decision Intelligence as an emerging managerial philosophy that integrates advanced analytical capabilities with holistic organizational objectives, offering both researchers and practitioners valuable insights into the future direction of industrial management.

## Future Research Agenda

The emergence of Decision Intelligence opens several promising avenues for future research that extend beyond the development of increasingly sophisticated analytical algorithms. While recent studies have demonstrated the value of integrating artificial intelligence, operations research, and advanced analytics into decision support systems, future investigations should focus on understanding how these technologies can be orchestrated into adaptive decision ecosystems. One important research direction involves developing unified Decision Intelligence architectures capable of combining predictive analytics, optimization models, simulation, digital twins, and explainable AI within a single decision environment. Such integrated platforms should support decision-making across strategic, tactical, operational, and real-time levels while maintaining transparency, traceability, and human oversight. Furthermore, greater attention should be devoted to the cognitive aspects of managerial decision-making, exploring how human expertise and

algorithmic intelligence can complement rather than replace one another in complex industrial settings.

Another important priority concerns decision-making under deep uncertainty. Existing industrial models frequently assume relatively stable probability distributions or predefined scenarios; however, many contemporary challenges, including geopolitical disruptions, climate risks, cyberattacks, and technological discontinuities, cannot be adequately represented through conventional assumptions. Future research should therefore investigate uncertainty-aware Decision Intelligence frameworks that integrate probabilistic reasoning, Bayesian learning, fuzzy inference systems, reinforcement learning, and scenario-based optimization. In addition, researchers should develop methodologies capable of continuously learning from streaming industrial data while dynamically updating recommendations as environmental conditions evolve. Equally important is the advancement of explainable and trustworthy Decision Intelligence, ensuring that increasingly autonomous systems remain transparent, interpretable, fair, and aligned with organizational objectives, ethical principles, and regulatory requirements.

Finally, future studies should broaden the application domain of Decision Intelligence beyond operational optimization toward enterprise-wide strategic transformation. Significant opportunities exist to investigate how Decision Intelligence can support sustainability transitions, circular economy initiatives, resilient supply networks, digital manufacturing ecosystems, and Industry 5.0 environments characterized by close collaboration between humans and intelligent machines. Cross-disciplinary research integrating industrial engineering, management science, behavioral decision theory, computer science, and organizational studies will be particularly valuable in advancing this agenda. Longitudinal empirical studies, real-world industrial experiments, and comparative international analyses are also needed to validate theoretical frameworks and measure the organizational impact of intelligent decision systems over time. Ultimately, future research should aim to establish Decision Intelligence not merely as a technological capability but as a comprehensive managerial paradigm capable of reshaping industrial management in an increasingly interconnected and uncertain world.

## Conclusion

Industrial management is experiencing a fundamental transition from optimization-centric thinking toward intelligence-driven decision ecosystems. As industrial systems become more interconnected, dynamic, and uncertain, the ability to make informed, adaptive, and transparent decisions has emerged as a primary source of organizational competitiveness. Decision Intelligence represents this new paradigm by integrating artificial intelligence, operations research, advanced analytics, human expertise, and intelligent decision support into a unified managerial capability. Rather than viewing data as an end in itself, Decision Intelligence emphasizes transforming information into actionable knowledge that enables organizations to anticipate disruptions,

evaluate alternatives, and continuously improve decision quality across all organizational levels. The contributions presented in this issue clearly demonstrate that this transformation is already underway across diverse domains of industrial management. Despite addressing different application contexts, the studies collectively reinforce the importance of analytical rigor, intelligent decision support, resilience, and sustainability in confronting the complexity of modern industrial environments. Together, they suggest that the future of industrial management will be defined not by isolated technological innovations but by organizations' ability to integrate human judgment, computational intelligence, and strategic foresight into coherent decision ecosystems. It is our hope that this editorial encourages further scholarly dialogue on Decision Intelligence and inspires researchers to develop the next generation of theories, methods, and applications that will shape the future of industrial management in an increasingly uncertain world.

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