

## Features of Decision Making Under Uncertainty

Muradov Shohjahon Dilshod O'g'li

Student, Tashkent State Technical University Named After I. Karimov, Uzbekistan

Ibragimova Saodat Abdumuminovna

Professor, Tashkent State Technical University Named After I. Karimov, Uzbekistan

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### Abstract

*The process of decision-making of managers under uncertainty is analyzed, risk and uncertainty are distinguished, and a probabilistic model is presented from the perspective of deep and radical uncertainty. The influence of cognitive aids of trusted managers, energy, trust, and bias on the quality of medical care decisions is highlighted. Theories are presented, and a basic conceptual model of environmental failures, managerial cognition, organizational processes and decision-making is proposed.*

**Keywords:** Uncertainty, risk, decision-making, managerial cognition, behavioral economics, strategy, organizational structure, dynamic experience.

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### 1. Introduction

Today, managers are forced to make decisions in rapidly changing, unpredictable conditions, where information is incomplete or uncertain [1]. In such conditions, it is important to distinguish between risk and uncertainty: as Knight (1921) [2] noted, risk is a situation where the outcome is unknown but the probabilities are known, while true uncertainty means that there are no even calculable probabilities. In practice, many business decisions are made under conditions of deep or radical uncertainty, because factors whose outcomes are not observed are insufficient for probabilistic planning. For example, global crises and the acceleration of technological change have repeatedly challenged managers' models and shown that traditional analyses

cannot capture "unknown situations."

In addition, psychological factors exacerbate the problem: managers are often overconfident and underestimate both positive and negative deviations, and they tend to evaluate the outcome rather than the quality of the decision (rewarding success and punishing failure). This article reviews recent research on managers' decision-making under uncertainty and develops a conceptual model that integrates environmental, cognitive, and organizational factors. The following sections summarize the main theories (Section 2), present an integrative model (Section 3), discuss practical implications (Section 4), and provide conclusions and future directions (Section 5).

## 2. Literature Review

The field of decision-making under uncertainty has been rapidly developing in recent years, as real-world problems often arise in situations where probabilities are not fully known or where there is deep uncertainty. Gilboa (2025) analyzes the dominance of expected utility theory and its empirical limitations (Allais and Ellsberg paradoxes) and highlights new directions, while Stanton et al. (2021) shows the practical effectiveness of DMDU methods in infrastructure projects. Badings et al. (2023) distinguishes between aleatory and epistemic uncertainties and discusses robust models and reinforcement learning approaches. Campello et al. (2022) reviews new methods for measuring uncertainty in corporate decisions (machine learning, big data) and the impact at the firm level, while Korem et al. (2025) offers new approaches to modeling uncertainty attitudes in qualitative outcomes. From this literature, we have taken into account the clear distinction between types of uncertainty, the robustness of DMDU methods, empirical evidence in corporate and healthcare contexts, and qualitative results, and justified the improvement of the decision process through the proposed integrated framework with recognition, classification, and iterative evaluation [6].

## 3. Methodology

A comprehensive methodological approach was used, aimed at comparative-critical study of literature and normative documents of education, analysis and observation, methods of studying and generalizing experiences, analysis of economic processes, and the use of inductive and deductive inference, statistical and economic analysis methods.

## 4. Results

**Theoretical Framework.** Decision theory and behavioral research offer complementary approaches to understanding uncertainty.

**Risk and Uncertainty.** In predictable environments (“risk conditions”), models of expected returns and statistical forecasts help guide decision-making. However, in real uncertainty, managers cannot know reliable probabilities. Caballero (2009, cited in MIT News) [2] argues that Knightian uncertainty perception can lead to a “flight to safety” in firms, i.e., decision paralysis. Modern research shows that irreversible uncertainty exists in almost all complex situations: volatile markets, rapid innovation, and sociopolitical

shocks make many outcomes unpredictable.

**Cognitive and behavioral factors.** Behavioral economists (Tversky and Kahneman, 1974) have shown that decision makers use heuristics that are effective in certain circumstances, but that these heuristics lead to errors in uncertainty. For example, managers often overestimate their understanding of outcomes and believe they understand them better than they actually do. Schweitzer (2021) [5] explains that this leads managers to underestimate the best and worst-case scenarios. Managers are also subject to outcome bias: they tend to attribute successful projects to good decisions. If failures (even if they are the result of reasonable risk-taking) are punished, employees become risk-averse, which is detrimental to long-term innovation. In conditions of high uncertainty, these biases can distort judgment if they are not controlled by conscious processes. For example, Kahneman (2011) [5] suggests institutionalizing review mechanisms (premortems, “red teams,” statistical comparison classes) to reduce individual errors in organizations. Schweitzer also emphasizes the need for leaders to “reward good decisions, not just positive outcomes.”

**Analytical and strategic tools.** Managers use a variety of frameworks to manage uncertainty. Scenario planning is a widely recommended approach: instead of relying on a single forecast, managers develop a number of plausible scenarios and prepare responses for each. By “pre-empting options,” scenario planning increases resilience when the future is uncertain. Other techniques include simulation, stress testing, and real options analysis, which increase management’s flexibility in the face of uncertainty. Mulford (2025) [4] outlines a “guide” for decision-making: managers should first determine the level of uncertainty they face (measured risk, strategic interdependence, or radical uncertainty) and then apply appropriate tools. For example, if the uncertainty is primarily related to competitor reactions, game theory and contingency planning are needed. If uncertainty is systemic (i.e., cannot be truly modeled), organizations should simplify their structures and create rapid learning cycles. In general, the literature suggests that there is no one-size-fits-all approach: decision performance depends on adapting analytical techniques to the nature of uncertainty.

**Organizational context.** Research also highlights the role of firm capabilities and culture. Extreme cases such as ASML (a semiconductor equipment leader) demonstrate the importance of building internal prediction networks

and parallel development teams for success in radical uncertainty. ASML managers consciously develop relationships with external experts and run multiple experimental R&D (research and development) lines in parallel, so they can adapt quickly to unexpected changes. Similarly, dynamic capabilities theory suggests that organizations that quickly re-adjust processes and learn from multiple sources manage uncertainty better. Campello and Kankanhalli (2024) [3] note that modern companies are increasingly using big data and machine learning to reduce uncertainty: algorithms can detect small changes and estimate “firm-specific uncertainty” from market signals. However, they caution that the analysis only captures quantitative variability, and that true uncertainty must be managed through strategic flexibility.

The quality of decisions under uncertainty is determined by (1) environmental factors (level and type of uncertainty), (2) cognitive biases and managerial experience, and (3) organizational processes and tools (analysis, planning, agility). However, most research examines these aspects separately. What is lacking is an integrative framework that shows how they interact. The next section brings these findings together into a conceptual model.

**Conceptual Model.** Based on the above discussion, we propose a conceptual model that integrates Environmental Uncertainty, Managerial Cognition, Organizational Processes, and Decision Outcomes.

- Environmental uncertainty spans a continuum from measurable risk to uncertainty. This external context defines the nature of the uncertainty that a manager faces (e.g., market volatility or completely new disruptions).
- Managerial cognition encompasses managers’ perceptions of risk, beliefs, and biases. For example, overconfidence in uncertain conditions can lead to underestimation of negative scenarios; conversely, high uncertainty can lead to poor decision-making or excessive caution. Cognitive framing is also important: if managers frame uncertainty as an external fact rather than a personal dilemma, they maintain their credibility.
- Organizational processes and tools refer to the methods and capabilities used. These include analytical tools (statistics, simulations) for quantitative risk, scenario planning and realistic choices for limited uncertainty, and flexible structures (e.g., agile teams, lean management) for total uncertainty. The model links tools to levels of

uncertainty, following Mulford’s “identify the right tool and apply it.”

- Decision outcomes—the final results, including performance and learning. When cognition and processes are aligned with the environment, good outcomes emerge. For example, delegating decision rights and encouraging rational risk-taking can enhance innovative choices in uncertainty. Conversely, outcome bias or overly centralized decisions can inhibit learning (organizations may avoid future risks out of fear of punishment). The model also assumes feedback loops: results refresh managers’ perceptions and prompt them to adapt processes (e.g., learning from premortem exercises).

Thus, the model describes decision-making under uncertainty as a dynamic system: external uncertainty shapes managerial thinking and the choice of tools, which in turn produce outcomes and influence future decisions.

## 5. Discussion

The proposed framework is consistent with and extends existing theory. It emphasizes that uncertainty is multidimensional and requires multifaceted responses. Classical decision theory provides tools for probabilistic risks, but our model suggests that additional mechanisms are needed as uncertainty increases. Psychological findings (e.g., Schweitzer 2021) [5][7] suggest that uncontrollable biases lead to systematic errors [1]. Our model reflects this by placing “managerial cognition” between the environment and the outcome, and implies that debiasing interventions (premortems, external vision) are an important mediator.

## 6. Conclusion and Recommendations

In conclusion, effective decision-making under uncertainty requires the integration of advances in psychology and strategy. Theories suggest that uncertainty ranges from quantitative risk to complete uncertainty, and that managers’ mental models and organizational systems must accommodate this difference. The proposed conceptual framework shows how environmental conditions interact with managerial cognition and organizational processes to shape outcomes. Future research should empirically test this model—for example, by measuring how different tools (scenarios and analyses) affect decision quality under different levels of uncertainty. For now, the framework serves as a guide for scholars and practitioners [1]:

recognizing the type of uncertainty, applying appropriate methods, and creating an organizational structure that allows learning regardless of the outcome. The practical implications are also clear [1]. As mentioned above, managers must first define uncertainty: is it a statistical risk or a new, unknown uncertainty? The former requires data analysis (looking beyond the averages). The latter, as Mulford recommends, requires flexible planning (scenario exercises, real-time sensitivity). Most importantly, incentives matter: organizations should reward the quality of decisions, not just positive outcomes. This means being tolerant of failure, even for decisions made through a rational process that may not yield immediate benefits (e.g., funding risky R&D projects that do not yield immediate results). Over time, this cultural shift will reduce the disruptive effects of biases in our model.

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