GAME THEORY AND PRACTICAL APPLICATION OF MATHEMATICAL CRITERIA

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Abstract: The article studies the mathematical models of stochastic and game theory of economic decision-making under uncertainty and risk. Unlike traditional models, it is necessary to determine the products that directly determine the functioning of the real business environment. As a research method, games with nature (Payoff matrix), Wald (Maximin), Maximax, Savage (Minimax methodology) and a set of Hurwitz criteria were used. table, example A matrix of strategies for various market scenarios in conditional production is compiled, and an algorithm for developing the most optimal strategy depending on the technical portrait of the manager (expert or cautious).

Keywords: risk and uncertainty, game theory, payoff matrix, Wald criterion, Savage criterion, Hurwitz criterion, decision making, operational design.

INTRODUCTION

The modern economy is an open system full of these and other scenarios. Most classical economic and mathematical models rely on exact (deterministic) data. Creating a void by accurately predicting the future, such as the struggle for recovery, inflation jumps or currency fluctuations. Such a situation is considered uncertainty in science.

When the decision-maker (manager or investor) has several alternative strategies and it is unknown how the organization will respond to the environment, decision-making must be transformed into a purely risk-based approach. The purpose of the article is to translate economic risks into strict mathematical matrices and to develop an algorithm for "interacting with nature" to minimize the optimal loss.

LITERATURE ANALYSIS

An analysis of risk experience modeling problems has shown that this field has developed in three distinct stages over the past century:

Fundamental Production: John von Neumann, considered the father of game theory, and Oskar Morgenstern mathematically represent uncertainty in economics as a "player versus nature conflict."

Criterion generation: In the mid-20th century, scientists such as A. Wald, L. Savage, and L. Gurvitz developed a special criteria formula that calculates the optimal decision for a manager's attitude to risk.

Current modern education: The level of operational workload in Uzbekistan. The scientific works of several scientists have highlighted the mechanisms of using matrix games in the national economy, in the development of logistics and investment programs. Nevertheless, a comprehensive comparison of all of them on the same basis and their presentation as a ready-made formula for management remains a practical task today.

RESEARCH METHODOLOGY

The product of the "playing with nature" methodology for solving the problem. Suppose that an economic agent has m alternative strategies: $A = \{A_1, A_2, \dots, A_m\}$. The flooded environment (state bo) can have n different image scenes: $П = \{П_1, П_2, \dots, П_n\}$. The Payoff matrix is formed from the three intersections:

$$P = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{pmatrix}$$

where a_{ij}- is the result (profit) obtained when the enterprise A_i chooses the strategy and the market $П_j$ follows.

Determining which A_i strategy is tested using 4 different mathematical criteria:

I. Wald criterion: The best possible improvement from the worst possible expected situation.

$$W = \max_i(\min_j a_{ij})$$

II. Maximax criterion: Taking risks only in the belief of the best outcome.

$$M = \max_i(\max_j a_{ij})$$

II. Hurwitz criterion: The coefficient $0 \leq \alpha \leq 1$ is introduced depending on the sign of the leader
($\alpha = 1$absolute risk, $\alpha = 0$ absolute need).

$$H_i = \alpha \max_j a_{ij} + (1 - \alpha) \min_j a_{ij} \rightarrow \max$$

III. Savage criterion (Minimax future): A "rich given" (regret) matrix is constructed and the minimum of the maximum losses in it is selected. Risk is: $r_{ij} = \max_i a_{ij} - a_{ij}$.

$$S = \min_i(\max_j r_{ij})$$

DISCUSSION AND RESULTS

To connect theory with practice, let's look at the picture. A furniture company has a strategy for producing products on 3 different scales: Large (A_1), Medium (A_2) and Small (A_3). It is unknown what the market demand will be and it can also be of 3 types: High demand ($П_1$), Medium demand ($П_2$) and Crisis/low demand ($П_3$). The expected profit (in million soums) is calculated by the enterprise economists, and the Payoff matrix is risk:

Strategies	**П1 (High demand)**	**П2 (Medium demand)**	**П3 (Crisis/Past)**
A_1**(Large scale)**	100	40	-20
A_2**(Medium scale)**	70	60	10
A_3 **(Small scales)**	40	30	20

Now we will sift this matrix through all mathematical criteria.

Step 1: Analysis by Wald (Maximin) criterion

Worst case in A_1: -20

Worst case in A_2: 10

Worst case in A_3: 20 Conclusion: $\max(-20,10,20) = 20$. So, a very cautious (pessimistic) manager chooses the strategy A_3(Small scale). Although he will miss out on a large profit, he will still come out with a profit of at least 20 million under any circumstance

Step 2: Analysis by Maximax Criterion

A_1 Highest need: 100

A_2 Highest need: 70

A_3 Highest probability: 40 Conclusion: $\max(100,70,40) = 100$. The aggressive manager, regardless of the company, chooses A_1 (Large scale) with a target of only 100 million.

Step 3: Analysis by Hurwitz Criterion (we assume $\alpha = 0.6$, i.e. the manager is 60% risk-taker, 40% cautious)

- $H_1 = 0.6(100) + 0.4(-20) = 60 - 8 = 52$
- $H_2 = 0.6(70) + 0.4(10) = 42 + 4 = 46$
- $H_3 = 0.6(40) + 0.4(20) = 24 + 8 = 32$

Conclusion: $\max(52,46,32) = 52$. For a balanced risk-taking manager, the A_1 strategy is the best.

Step 4: Savage (Rich Chance) Analysis First, we construct the matrix. We find the largest numbers by column: $П_1$ max = 100; $П_2$ max = 60; $П_3$ max = 20. We subtract each cell from these maxima:

Strategies	**П1 (Subtract from 100)**	**П2 (Subtract from 60)**	**П3 (Subtract from 20)**	**The Biggest Risk (Regret)**
A_1	$100 - 100 = 0$	$60 - 40 = 20$	$20 - (-20) = 40$	**40**
A_2	$100 - 70 = 30$	$60 - 60 = 0$	$20 - 10 = 10$	**30**
A_3	$100 - 40 = 60$	$60 - 30 = 30$	$20 - 20 = 0$	**60**

Conclusion: The largest buildings (regrets) are 40, 30, and 60. The Savage criterion dictates that we choose the smallest of these $\min(40,30,60) = 30$. Therefore, the strategy with the least regret is -A_2 (Medium scale).

CONCLUSIONS AND SUGGESTIONS

Game theory and mathematical criteria analysis show that there is no single "absolutely correct" solution to economic risk and uncertainty. The choice directly depends on the mathematical criterion being adopted and the business situation. Suggesting help in the analysis:

1.The medical-mathematical basis of strategic choice: If the organization is in a position to make a profit and does not want to go bankrupt, the manager must switch from the Wald (Maximin) criterion to a defensive strategy (A_3). If the enterprise has sufficient management capital, it is possible to act aggressively according to the Maximax or Gurvitz (A_1) criterion to capture the market.

2.Advantages of the Savage criterion: The most optimal method for participating in market fluctuations as a participant is the Savage criterion. Because it avoids both extreme risks and extreme beginnings, and minimizes the regret of falling behind children (A_2) in any scenario.

3. When passing business plans through state expertise or the credit committee of banks, it is necessary to clearly calculate financial optimistic returns, as well as high-level payment matrices and large criteria, which will dramatically improve the quality of risk management.

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