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# MODELING THE PROCESSES OF ADAPTING A COMPANY’S PRODUCTION STRATEGY UNDER MARKET PRICE INSTABILITY

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*Problem Statement.* Under conditions of fluctuating market prices for resources and finished products, enterprises require rapid adaptation of their production strategies. The instability of the external environment and price risks complicate the process of managerial decision-making. To improve the effectiveness of strategic management, economic and mathematical modeling is applied. *The purpose of the article* is to develop an approach to modeling the processes of adapting a company’s production strategy under market price instability, based on the methods of linear programming and game theory, which make it possible to optimize managerial decision-making in situations of risk and competition. *The object of the study* is the process of adapting the company’s production strategy to changes in market prices for resources and finished products. The methodological foundation is formed by a systems approach to strategic enterprise management, methods of economic and mathematical modeling, particularly linear programming, and elements of game theory. *The main hypothesis* assumes that the use of economic and mathematical models enhances the effectiveness of the company’s production strategy adaptation by ensuring a rational choice of managerial decisions under conditions of price uncertainty and competitive pressure. *Main Material Presentation***.** The article presents a step-by-step approach to constructing a model for adapting the production strategy using linear programming methods to determine the optimal production structure and game theory tools to analyze the strategic behavior of an enterprise under various market price fluctuation scenarios. *The originality of the research* lies in combining linear programming methods and game theory to model the process of adapting the production strategy. The practical significance of the study is determined by the possibility of applying the proposed approach to increase the effectiveness of strategic management of enterprises under market price turbulence. *Conclusions and Prospects for Further Research.* The pro-

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posed linear programming models and elements of game theory help optimize the production structure and predict enterprise behavior in a competitive environment. Promising directions for further research include integrating adaptation models with scenario planning, risk management, and digital decision-support tools.

**Keywords:**
adaptation of production strategy, economic and mathematical modeling, linear programming, game theory, strategic management.

## МОДЕЛЮВАННЯ ПРОЦЕСІВ АДАПТАЦІЇ ВИРОБНИЧОЇ СТРАТЕГІЇ ПІДПРИЄМСТВА В УМОВАХ ЦІНОВОЇ НЕСТАБІЛЬНОСТІ РИНКУ

*Постановка проблеми.* В умовах коливань ринкових цін на ресурси та готову продукцію підприємства потребують швидкої адаптації своїх виробничих стратегій. Нестабільність зовнішнього середовища та цінові ризики ускладнюють процес прийняття управлінських рішень. Для підвищення ефективності стратегічного управління буде використано економіко-математичне моделювання. *Метою статті* є розроблення підходу до моделювання процесів адаптації виробничої стратегії підприємства в умовах цінової нестабільності ринку на основі методів лінійного програмування та теорії ігор, що дозволяють оптимізувати прийняття управлінських рішень у ситуаціях ризику та конкуренції . *Об'єктом дослідження* виступає процес процес адаптації виробничої стратегії підприємства до змін ринкових цін на ресурси та готову продукцію. *Методологічну базу* становлять системний підхід до стратегічного управління підприємством, методи економіко-математичного моделювання, зокрема лінійного програмування та елементи теорії ігор. *Основною гіпотезою* є припущення, що використання економіко-математичних моделей дозволяє підвищити ефективність адаптації виробничої стратегії підприємства, забезпечуючи раціональний вибір управлінських рішень за умов цінової невизначеності та конкурентного тиску. *Виклад основного матеріалу.* У статті представлено поетапний підхід до побудови моделі адаптації виробничої стратегії з використанням методів лінійного програмування для визначення оптимальної структури виробництва та інструментів теорії ігор для аналізу стратегічної поведінки підприємства за різних сценаріїв зміни ринкових цін. *Оригінальність дослідження* полягає у поєднанні методів лінійного програмування та теорії ігор для моделювання процесу адаптації виробничої стратегії. *Практична значимість роботи* визначається можливістю використання запропонованого підходу для підвищення ефективності стратегічного управління підприємствами в умовах цінової турбулентності ринку. *Висновки та перспективи подальших досліджень.* Запропоновані моделі лінійного програмування та елементи теорії ігор допомагають оптимізувати структуру виробництва та прогнозувати поведінку підприємства в конкурентному середовищі. Перспективними напрямками подальших досліджень є інтеграція моделей адаптації зі сценарним плануванням, ризик-менеджментом та цифровими інструментами підтримки управлінських рішень.

**Ключові слова:** адаптація виробничої стратегії, економіко-математичне моделювання, лінійне програмування, теорія ігор, стратегічне управління.

**Formulation of the problem.** In the modern context of globalization and intense competition, enterprises face constant changes in market conditions that directly affect the efficiency of their production activities. One of the key factors determining an enterprise's success is its ability to promptly adapt production strategies to fluctuations in the prices of material resources and finished products. Market price fluctuations create conditions of uncertainty that can significantly influence production costs, profitability, and the competitiveness of products.

In academic literature, the term *price turbulence* is used to describe market conditions in which prices for resources and finished goods change unpredictably and rapidly, creating increased risks for enterprises. Price turbulence is characterized by a high amplitude and frequency of price fluctuations, uncertainty regarding their direction, and the impossibility of accurate forecasting. Under such conditions, traditional methods of strategic planning and production management prove insufficiently effective, as they are often based on stable market parameters and medium-term forecasts.

Market uncertainty associated with price turbulence complicates the managerial decision-making process. Enterprises must solve complex tasks such as selecting optimal production volumes, planning material procurement, determining the structure of product output, and adjusting strategic priorities according to market conditions. Classical planning approaches based on fixed forecasts and average statistical data fail to account for rapid price changes and competitor behavior.

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To improve the effectiveness of managerial decisions under such conditions, it is necessary to apply methods of economic and mathematical modeling. These include linear programming, which makes it possible to determine the optimal allocation of resources and production capacities, and game theory, which enables the prediction of an enterprise's strategic behavior in a competitive environment. The application of these methods allows for a quantitative description of the adaptation process of a production strategy, consideration of risks and uncertainty, and substantiated managerial decision-making.

Modern enterprises must be capable of responding flexibly to market fluctuations, quickly adjusting production plans, reallocating resources, modifying product output structures, and applying different development scenarios. Such flexibility reduces losses from price fluctuations, optimizes costs, and increases profitability. Effective adaptation of the production strategy thus becomes not only an internal competitive advantage but also a prerequisite for survival in an unstable market.

Therefore, the problem statement centers on developing an effective approach to modeling the processes of adapting an enterprise's production strategy in situations of market price turbulence, an approach that would take into account risks, changing market conditions, and the competitive behavior of market participants. This issue is relevant for both industrial enterprises and small- and medium-sized production businesses, where fluctuations in material and product prices can significantly affect financial results and strategic decisions.

Economic and mathematical modeling in this context allows to:

– determine the optimal production structure and resource volumes for each type of product;

– analyze enterprise behavior in a competitive environment under various price change scenarios;

– increase the accuracy of managerial decisions and minimize financial risks;

– ensure strategic flexibility of the enterprise under market instability.

The proposed approach combines economic and mathematical methods with the concept of adaptive management, enabling enterprises to improve production efficiency even in complex and unstable market conditions.

**Analysis of Recent Research and Publications.** Key theoretical foundations of strategic management are presented by Ansoff [1], Mintzberg et al. [2], and Porter [3], who outline major approaches to strategy formation, competitive positioning, and long-term planning. Drucker [4] emphasizes managerial adaptation and innovation as essential elements for effective strategic decision-making.

Modern Ukrainian scholars also explore issues of adaptability and enterprise resilience. Havrysh, Rakov, and Buich [5] examine mechanisms for adapting economic systems to turbulent environments, while Hudz, Nechaeva, and Yeskov [6] propose a toolkit for managing production potential. Rosokhata [7] offers classifications of economic-mathematical modeling methods relevant for forecasting enterprise development.

Further methodological contributions come from studies in price modeling and game theory. Gomes, Gutierrez, and Ribeiro [8] analyze price formation under random supply, and Gomes, Gutierrez, and Laurière [10] apply machine learning to price models with common noise. Murota [9] develops tools of discrete convex analysis applicable to strategic economic modeling.

Research by Kravchuk, Rymar, and Bortnik [11] focuses on modeling enterprise economic development in crisis conditions, providing analytical approaches for scenario assessment.

Modern research focuses on the use of linear programming, game theory, and scenario analysis as tools for building adaptive models of strategic management. However, there remains a lack of comprehensive studies that combine optimization methods with analyses of enterprise strategic behavior under market volatility.

**The purpose of this article** is to substantiate theoretical foundations and develop approaches to adapting an enterprise's production strategy under conditions of market price turbulence through the application of economic and mathematical modeling.

**Presentation of the Main Research Material.** In the modern market economy, enterprises operate in an environment characterized by a high level of instability and unpredictability. One of the key manifestations of this instability is price turbulence, characterized by frequent and significant fluctuations in market prices for raw materials, energy resources, intermediate goods, and finished products. Such turbulence may result from external factors, such as

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inflationary processes, currency fluctuations, or changes in global price trends, as well as internal ones, including reduced demand, logistical challenges, and supply chain disruptions. As a result, enterprises continually face the need to adapt their production strategies to rapidly changing environmental conditions.

The process of adapting a production strategy involves flexible resource reallocation, changes in production structure, adjustments in output volumes, and modifications of enterprise pricing policy. The primary goal of adaptation is to ensure the economic stability of the enterprise, minimize the impact of price risks, and maintain competitiveness in both the short and long term. Achieving this requires not only continuous monitoring of the current market situation but also forecasting potential scenarios of change, necessitating the use of quantitative analysis and forecasting methods.

In this context, economic and mathematical modeling serves as an effective tool for research and managerial decision-making. It enables the formalization of relationships between key variables of the production process, consideration of external factors, and determination of optimal solutions under resource constraints and uncertainty. The application of linear programming models makes it possible to develop an optimal production program for various price change scenarios, while the use of game theory elements allows for the consideration of competitors' strategic behavior in the market.

The problem of selecting, from a possible "order portfolio," the most profitable production mix for a given enterprise under specified conditions reduces to a decision-making problem under certainty when the following are known:

– market prices for finished products $C_j j = \overline{1,\dots,n}$, and for material resources $C_m$;

– the minimum industry wage level $d$;

– labor intensity $t_j$ and material intensity $H_{pj}$ for producing item $j \in \{1,\dots,n\}$;

– available production capacity $T_{\text{annual}}$ and financial resources $D$.

The formulated problem is equivalent, from the profit-maximization viewpoint, to finding non-negative quantities $x_j \geq 0$ of the given product types $j \in \{1,\dots,n\}$, each characterized by labor intensity $t_j$ and material intensity $H_{pj}$, under constraints of available annual production capacity $T_{\text{annual}}$ and funds $D$, provided that prices for finished products, material and labor resources are known.

Assume the market for the enterprise's products is perfectly inelastic in demand, i.e. changes in the price $C_j$ do not affect the required quantity $x_j$. Then the profit $P$ of the producer, as a function of output vector $\mathrm{X} = (x_1,\dots,x_n)$, can be written formally as (1)

$$P(\mathbf{x}) = \sum_{j=1}^{n} C_j x_j - B, \qquad (1)$$

where $B$ denotes the producer's production costs.

Production costs can be represented as the sum of variable (direct) and quasi-fixed (indirect) costs (2):

$$B = B_{\text{var}} + B_{\text{fixed}}. \qquad (2)$$

Variable production costs are costs that are directly proportional to the output volume (3):

$$B_{\text{var}} = \sum_{j=1}^{n} S_j x_j, \qquad (3)$$

where $S_j$ are the direct costs of producing one unit of product $j$.

Quasi-fixed (indirect) costs are costs associated with servicing and managing the whole production.

The problem also requires finding non-negative output volumes $x_j \geq 0$, $j \in \{1,\dots,n\}$, that maximize the objective function (4):

$$\max_{\bar{x}} \left( \sum_{j=1}^{n} (C_j - S_j)\, x_j - B_{\text{fixed}} \right), \qquad (4)$$

subject to production capacity and budget constraints (5):

$$\sum_{j=1}^{n} t_j x_j \leq T \;,\; \sum_{j=1}^{n} S_j x_j + V_p \leq D, \qquad (5)$$

where $V_p$ denotes other relevant parametric expenditures.

The formulated problem is equivalent to the linear programming (LP) problem (6):

$$\begin{aligned} &\max_{x}\ \bar{k} \cdot \bar{x}, \\ &A \cdot \bar{x} \leq \bar{b}, \\ &\bar{x} \geq 0, \end{aligned} \qquad (6)$$

where $\bar{x} = (x_1,\dots,x_n)$ is the vector of output volumes;

$\bar{k} = (k_1,\dots,k_n)$ is the vector of objective coefficients with

$$kj = sj \times (\overline{C_j} / 100\% - 1),\ \forall\, j \in \{\overline{1,n}\};$$

$$A_i = \begin{pmatrix} t_1,\dots,t_n \\ S_{i1},\dots,S_{in} \end{pmatrix}$$

is the matrix of technical-economic coefficients characterizing production of items $j$; and $\bar{b} = (b_1, b_2)$ is the constraint constant vector with $b_1 = T$ and $b_2 = D - V_p$.

The above LP problem, which has only two constraints, can be solved by a graph-analytic method using the dual problem.

For each $i$ -th price level $\bar{C}_i = (C_{i1}, \dots, C_{in}, C_{m_i}, d_i), i \in \{1,2\}$, solving the LP problem (7):

$$\max_{\mathbf{x}} \bar{k}_i \bar{x}, \quad A_i \mathrm{x} \le \mathrm{b}_i, \mathrm{x} \ge 0, \qquad (7)$$

yields the corresponding optimal production programs $x^{(i)}$,

$$\bar{x}^{(i)} = \left(x_1^{(i)}, \dots, x_n^{(i)}\right), i \in \{1,2\},$$

It is necessary to determine an optimal production strategy

$$\bar{x}^{(*)} = \left(x_1^{(*)}, \dots, x_n^{(*)}\right),$$

that guarantees the maximum guaranteed profit under uncertainty of the external environment. This task can be solved using the theory of (strategic) games: construct the matrix of possible profits (8):

$$P = (P_{ki})_{\substack{k=1,2, \\ i=1,2}}. \qquad (8)$$

One should find a partial resource allocation $0 \le p_i \le 1$ $(i = 1,2)$ between the pure production strategies $\bar{x}^{(i)} (i = 1,2)$, such that, regardless of the realized price level $\bar{C} \in \{C_1, C_2\}$, the guaranteed profit is maximized. If we assume that the firm's profits are proportional to production volumes, and those volumes are proportional to allocated resources, then the problem reduces to a matrix game: determine the value of the game $(\gamma)$ and the optimal strategy that attains it. The mixed strategy is (9):

$$\bar{x}^* = p_1 \bar{x}^{(1)} + p_2 \bar{x}^{(2)}, \qquad (9)$$
$$p_1 + p_2 = 1.$$

To solve this, determine the lower $(\alpha)$ and upper $(\beta)$bounds of the game value (10; 11):

$$\alpha = \max_i \min_j \mathrm{P}_{ij}; \qquad (10)$$

$$\beta = \min_i \max_j \mathrm{P}_{ij}. \qquad (11)$$

If the lower and upper bounds coincide, which indicates the existence of a saddle point in the matrix game under consideration, the game value $(\gamma)$ the guaranteed maximum payoff is determined by one of the pure strategies $\bar{x}^{(i)} \in \{\bar{x}^{(1)}, \bar{x}^{(2)}\}$, which ensures the maximization of the result under the most adverse conditions (12):

$$\gamma = \max_i \min_j P_{ij}. \qquad (12)$$

In this case, the optimal strategy is defined as (13; 14):

$$\bar{x}^* = \rho_i x^{(i)}, \qquad (13)$$
$$\textstyle\sum_{i=1}^{2} \rho_i = 1. \qquad (14)$$

If the lower and upper bounds of the game value do not coincide $(\alpha < \beta)$, then to obtain the maximum guaranteed payoff, the game-theoretic problem must be reduced to solving the dual problem of linear programming.

Accordingly, the enterprise's risk-free (maximin) production strategy is obtained as (15):

$$\begin{aligned} \bar{x}_1^* &= p_1 x_1^{(1)} + p_2 x_1^{(2)}; \\ \bar{x}_2^* &= p_1 x_2^{(1)} + p_2 x_2^{(2)}; \\ &\dots \quad \dots \quad \dots \quad \dots \\ \bar{x}_n^* &= p_1 x_n^{(1)} + p_2 x_n^{(2)}, \end{aligned} \qquad (15)$$

which ensures the highest guaranteed profit under uncertainty in input and output prices.

The derived risk-free production strategy provides the maximum guaranteed payoff in the presence of uncertainty regarding resource and product prices. In other words, the key objective of adaptation is to ensure the enterprise's economic resilience, minimize the influence of price volatility, and maintain competitiveness in both the short and long term.

Thus, economic-mathematical modeling functions as an effective tool for enhancing the efficiency of strategic enterprise management under market turbulence.

**Conclusions and prospects for further research.** The study substantiates the need to adapt the enterprise's production strategy to conditions of price turbulence in the market. It has been proven that the application of economic and mathematical modeling, particularly methods of linear programming and elements of game theory, makes it possible to improve the efficiency of strategic management through the quantitative justification of managerial decisions. The obtained risk-free production strategy ensures the maximum guaranteed profit under uncertain prices for resources and finished products, thereby reducing the impact of external risks and strengthening the enterprise's financial stability.

The research results have practical value for enterprises across various industries operating in unstable market environments. The proposed approach can be applied to production volume planning.

Promising directions for further research include improving the adaptation model by integrating it with scenario planning, risk management, and decision support systems. It is also advisable to develop digital tools that would automate the modeling process and enable real-

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time monitoring of production strategy effectiveness.

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