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MATHEMATICAL MODELLING OF THE PRICE DETERMINATION PROCESS FOR THE PRODUCTION OF FOOD COMPANIES

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Abstract

The managers of every food production and catering company have to deal with the issues of determining the price of food products, meals, and drinks as well, which are relevant in the current global economic conditions. We see the choice of pricing policy in for-profit food production and catering companies as a scientific problem of our time. The purpose of the article is to offer reasonable mathematical models for calculating the prices of food-manufacturing products or meals and drinks.

Admittedly, there is a paucity of scientific publications devoted to the justification of pricing for food service establishments, and we found this niche requires sound systematic research. While searching for information in scientific sources for the development of mathematical models, we had to summarize the scientific opinions of many researchers, based on which we created and described possible mathematical expressions for determining the price of food production. In the article, we presented a mathematical model of 3 methods for determining prices for food and catering companies. The presented methods are called a basic (it is most suitable for food business beginners seeking to understand how this business works), derivative (for more advanced entrepreneurs who already know the ins and outs of the food production process and understand the market's needs) and blind pricing method (for business professionals applying quantitative accounting of food products). The application conditions of each method, its advantages, and disadvantages are explained. It is even proven that the proposed methods are suitable for the application of an artificial intelligence system in solving food inventory and raw material quantity management issues with suppliers.

Understanding these methods will allow food production and catering companies to choose the most appropriate food pricing methodology by the mathematical expression that meets current conditions and allows them to cope with global economic challenges.

***Key words**: Mathematical modeling, Price determination, Food companies.*

1. Introduction

The level of the economies of countries around the world is based on the results of enterprises' commercial activities. The well-being of the people in each country and social guarantees largely depend on them. The activities of enterprises are usually regulated by the laws for enterprises. They define the concept of a company: "An enterprise is an economic unit with its trade name, established in the manner prescribed by law for certain commercial activities" [1]. The company consists of a complex of materials, financial and material assets, its rights and obligations. Each food-producing enterprise unites a certain collective of employees, has at its disposal the means of production, and raw materials, and performs production functions, and catering enterprises perform the functions of organizing not only the production, and sale but also the consumption of dishes and beverages.

In most countries around the world, cooking is a business that generates income for business owners and company employees [2]. However, in some countries, there are quite a few non-profit catering enterprises that are owned by other economic entities. For example, the canteens of preschool institutions,

and part of the secondary school canteen belong to the city education departments, and there are the hospitals' canteens, state rehabilitation centers, and boarding houses belong to the health departments of self-government or the Ministry of Health, and the canteens of military units - to the Ministry of National Defence. More and more states and these catering enterprises are objects of private business. Thus, the trend is clear: food production and food services in most countries are gradually moving to private equity ownership and becoming commercial objects [3].

The managers of each food production and catering company have to deal with the pricing of food products, dishes, and beverages, which are more relevant for profit-making catering companies [4]. Non-profit companies sell dishes and drinks at cost and do not carry out any interpretations of the price calculation. Simply the calculated price of a set of raw materials is considered to be the selling price of the dish [5].

We saw the choice of pricing policy in for-profit food production and catering enterprises as a scientific problem of today. The purpose of the article is to propose reasonable mathematical models for calculating the prices of food production products and dishes and drinks.

2. Mathematical modeling of the price determination process for the production of food companies

It must be admitted that there are not many scientific publications devoted to catering enterprises to justify the calculation of prices: a study of the possibilities and willingness of consumers to pay the specified price of dishes [6], about the increase in the price of healthy food [7], the exceptional factors that determine the price of dishes [8, 9, and 10], etc. Unfortunately, these publications do not provide a systematized, scientifically based methodology for determining the possible price of food products and dishes, based on mathematical models, suitable for food production and catering companies.

Food production and catering enterprises in practice use different methods of determining the price of products without any reasoning of differences and systematic and logical justification. In the search for information in scientific sources for the development of mathematical models, it was necessary to summarize the scientific opinions of a large number of researchers, based on which one can single out the main method of determining the cost of production, which is the most popular in these enterprises [11, 12]. After evaluating the necessary actions, the following formula could express the mathematical model of this method:

$$G = (T + \frac{TA}{100})\frac{V_c}{100} \quad (1)$$

Where: G is the final selling price of a dish or drink; T is the price of a set of raw materials for the dish; A is the mark-up of the dish in percentage terms; V_c - the amount of value added tax as a percentage fixed by the law of each country. The amount of value-added tax, as a rule, is different in many countries of the world.

The cost of a set of raw materials T is calculated based on the quantities of raw materials indicated in the recipe of the dish. Chefs of catering enterprises can vary in quantities of raw materials, and look for the best option until the recipe for each dish is approved. Mark-up A can be fixed and flexible [13]. A fixed markup is calculated, as a rule, in the catering enterprises of the pioneers (newcomers, to simplify the organization of accounting for raw materials). In new companies, owners usually have many other problems and issues to be solved only after opening, so this simplest accounting system is the most favorable after starting this business. In such enterprises, as a rule, accounting for raw materials in monetary terms is used. Thus, a constant (fixed) markup is called such when a markup of the same size (in percentage terms) is calculated for all raw materials in stock or received. We will also call a constant (fixed) markup of the same size, which is equally calculated for all dishes. The calculation of a constant (fixed) markup requires less cost, and simpler control over the accounting of raw materials [12], therefore this method is recommended to be applied to new (only opened) food production and catering enterprises.

In this case, if, for example, the price of a set of raw materials for a dish is 5 Euros, a mark-up of 200%, and the value-added tax in Lithuania is 21%, then the selling price of such a dish would be 18.15 Euros. The results can be presented in the Table 1:

Table 1. Price calculation

Name of the raw material	The amount of raw material in the product or dish according to the recipe	Raw material price, Euros	Relative cost of raw material in a product or dish, Euros
1.			
2.			
n			
Total (the cost of a set of raw materials):			5
Mark-up 200 %, Euros			10
Value added tax			3.15
Selling price, Euros			**18.15**

Similarly, the price can also be determined in a derivative way, i.e. when the mark-up is set, it can

vary differently for each product or group of products. The variation of markups is suitable for use in food production and catering establishments [14]. In this case, after considering all the conditions and circumstances of the calculation, the price of the dish would be calculated according to the following formula (12):

$$G = \sum B_n (1 + \frac{K_n}{100}) \frac{V_c}{100} \quad (2)$$

Where: B_n - the cost of the nth quantity of raw material included in the dish; K_n - *the* mark-up of the nth raw material in percentage terms; V_c - the same amount of value added tax as a percentage.

The numbers in the Table 2 should look like this:

Table 2. Price calculation in a derivative way

Name of the raw material	The amount of raw material in the product or dish	Raw material price, Euros	Relative price of raw material in a product, or dish, Euros	Mark-up, Euros	Price with mark-up, Euros
1.					
2.					
n					
Total					
Value added tax					
Selling price					

The size of the mark-up is usually determined by the heads of the catering company, considering the situation in the market of food raw materials, and the expected demand for food products or dishes. The markup may be set differently for individual groups of foods (e.g. meat, dairy products, vegetables, or alcoholic beverages) or may be set differently for any one raw material (e.g. ginseng's natural root, etc.) [15, 16].

This method is popular because the application of a flexible (different for individual products) mark-up allows you to increase the mark-up (i.e. differentiate) the mark-up on foods (raw materials), which require more additional costs than, as a rule, for other products. For example, the transportation of some specific raw materials from other countries usually entails additional costs, which are compensated by a higher mark-up. The use of specific raw materials, such as exotic spices, usually enriches and diversifies the taste of food products or dishes, and therefore can add to the unique characteristics of a food production or catering company and at the same time increase the competitiveness of such a company.

Both of the above methods of pricing dishes make it possible to determine the price of the dish accurately, with the accuracy of small money (coins-cents).

The third method of pricing dishes can be identified as a blind selection of prices [12]. This is the most widely used pricing method at the moment. Its essence is as follows: for a start, the cost of the raw materials that make up the dish is calculated (the cost of a set of raw materials). After further assessing the cost of production, the ability of consumers to buy, their attitude to a particular food, seasonality, and other factors [7, 8, 9, and 10], the managers of the food production or catering company decide what the price of this dish could satisfy consumer demand. In this way, the price is set blindly. Here it is important not to make a mistake. The above factors can also determine the amount of the mark-up, the price being determined by the above methods. Although the blind method of price selection is still considered to be the most flexible, the price of a food product or dish set in this way can best meet the needs of the market. The selling price of dishes, determined by this method, can be changed even during the day, for example, if you notice that it is set too high, that the reaction of visitors is inadequate to the established price of a food product or dish. In this case, to invigorate the sale of such a product, it is appropriate to set a lower price. A reverse solution is also possible: having determined that the popularity of the product of such an enterprise is too high, potentially inadequate for the cost of its production, it makes sense to increase the selling price of the dish. In this case, another question is relevant for the company's managers: how to determine the added value brought to the company by the dish, determining the cost of the dish by this method? At first glance, the calculation of the mark-up is logical and simple: from the blindly determined flexible sale price, you need to subtract the cost of a set of raw materials and pay the necessary value-added tax. Since value-added tax is to be deducted, its value will be different from the added tax [17, 18]. The value-added tax deducted shall be calculated in such a case as follows:

$$V = \frac{100 V_c}{100 + V_c} \quad (3)$$

Where: V is the deductible amount of value-added tax as a percentage.

As mentioned above, when calculating the mark-up of a dish in monetary terms, we further derive the following formula based on the necessary logical actions:

$$V = C - \frac{100 V_c}{100 + V_c} - T \quad (4)$$

Where: C is the blindly selected price of the dish in monetary terms; T is the cost of the dish (the price of a set of raw materials) in monetary terms.

The prices fixed(s) by this method are normally rounded to an integer. Such rounding makes it more convenient for consumers to pay for food products (in particular, for dishes and drinks with waiters and cashiers in catering enterprises) and facilitates the work for persons who make settlements with other buyers of food companies' products. This method is usually applied when accounting for raw materials in quantitative terms.

All of the above methods of determining the prices of food production are tied to the accounting of raw materials in the warehouse, therefore their application allows computerized processes, even by combining accounting into a common network with suppliers. In this way, suppliers can control the possession of the necessary quantities of raw materials, know the quantities of raw materials in warehouses, and at the same time ensure the elimination of the shortage of raw materials. That would be the application of the potential of artificial intelligence in the field of stock management of food production companies [19, 20].

3. Conclusions

- To date, neither the scientific nor the special literature provides a clear and systematized methodology for determining the price of dishes, which could be applied both in catering enterprises and in other food production institutions. The lack of such a methodology is a gap in science and a relevant scientific issue for these enterprises, the solution of which would facilitate the costs of accounting workers. The mathematically modeled methodologies proposed in the article are easily applied in computerized applications, so they can be the basis for the application of artificial intelligence in the field of food inventory management.
- The article proposed 3 methods for determining the prices of dishes and drinks of food products or catering enterprises: the main method, the derived method, and the blind method of price selection. The procedure for applying these methods has been clarified, their advantages and disadvantages depend on the situation of the company. All proposed methods are based on mathematical expression.
- An understanding of these methods will allow food production and catering companies to choose the most appropriate methodology for determining the price of food following current conditions and allowing them to cope with global economic challenges.

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