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Application of an economic-mathematical model for the development of a marketing strategy and marketing plan for a small business in the hospitality industry

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Abstract

Developing a marketing strategy for a restaurant business is quite a complex task from a decision-making point of view, as different criteria and constraints, different situations in which rational (suboptimal) or optimal decisions have to be made, etc. have to be taken into account.

Marketing strategies should be developed taking into account different scenarios, which allows the formulation of some criteria and restrictions necessary for the use of certain methods of economic and mathematical modeling. At the same time, marketing strategies developed taking into account the results of economic-mathematical modeling allow for a more comprehensive analysis of possible solutions and the selection of the best ones.

This article presents the development of a set of economic and mathematical models for creating a marketing strategy and plan using the example of a small business in the restaurant industry. The authors have developed an optimization model and obtained optimal solutions for a marketing plan for a restaurant considering a given objective function and a system of constraints on variables that characterize the external and internal environment of the restaurant and the main business processes.

***Keywords**: marketing strategy, marketing plan, restaurant operation, optimization model*

INTRODUCTION

Marketing strategy is a comprehensive plan for business development aimed at attracting customers, increasing sales and boosting profits [4]. The development of a company's marketing strategy focuses on a long-term development plan. Its main goal is the conceptual control of the entire marketing of the company [4, 16]. In addition, tactical marketing is aimed at attracting and retaining customers, creating demand for products in the current sales market and increasing profits through sales. These parameters are defined in the marketing plan, which is developed for both medium-term goals and operational planning. Tactical marketing is characterized by a short-term planning horizon. Operational marketing focuses on the application of the most effective implementation methods, the use of trade marketing tools and cost minimization. Its task is also to meet the indicators defined in the operational plan (e.g. achieving a certain level of sales, ensuring the profitability of various products, territories, markets and distribution channels). Tactical marketing includes the following elements: sales promotion, development of alternative methods of finding and attracting distributors; analysis of the assortment policy of retail distributors and the distribution network; planning of optimal presentation of goods and effective merchandising at the point of sale; development of sales promotion measures; determination of the pricing strategy for retail sales and distributors [9, 10].

The restaurant's marketing strategy is based on marketing planning [1, 5]. Decisions on marketing strategy should be based on the results of analyzing market conditions, identifying the target audience and market, acceptable marketing budget and available promotional tools. The system of manageable elements of a restaurant's marketing strategy (marketing mix) includes: 1) determining the location, 2) determining the range of services, 3) describing the competitive environment, 4) selecting the target audience, 5) pricing policy, 6) planning promotional activities for services, 7) selecting suppliers, 8) working with staff [6, 16]. As an integral part of the overall corporate strategy, the marketing strategy directs activities towards achieving the following strategic goals: 1) increasing the company's market share; 2) increasing the company's sales; 3) increasing the company's profit; 4) achieving a leading position in the market, etc. [2, 6, 14]. [2, 6, 14]. [2, 6, 14]

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At the same time, the objectives of the marketing strategy must necessarily be aligned with the company's mission and its overall global objectives [2, 14].

To achieve any of the above objectives, the restaurant industry needs to develop a marketing strategy based on the following elements: 1) target audience and consumer segmentation; 2) marketing mix (7 "P's": product, distribution, price, promotion, physical environment, process, personnel); 3) marketing budget [2].

As D. Shumilova and U. Kuznetsova noted, when planning advertising for a restaurant or chain, it is important to focus on the specifics of the area, paying special attention to the needs, motives and pains of the target audience [17]. An important factor is the patterns of consumer behavior, information factors (trends) and the emotional component [8]. The modern audience, represented by the young and middle-aged generation, has developed a pattern of studying information about restaurants online [3, 11]. Functional features such as online reservation, food delivery and online communication with restaurants have also had a great influence on the formation of this behavior. If a restaurant does not have an online presence, it significantly reduces its chances of attracting new customers, as the usual path of users is interrupted [12, 13, 15]. Specific advertising media are selected depending on the objective. Each channel can be useful, it is just important to clearly understand the purpose and the metrics to measure that benefit. The basic tools that usually bring the highest amount of traffic and revenue are based on the specifics of the field and the consumption habits of the audience [6, 7].

The problems of developing marketing strategies for different types of restaurants have been addressed in various papers [1, 3, 16, 17], but only conceptual models have been presented without applying quantitative methods. Other works such as [3, 7, 8, 15] present methods of applying artificial intelligence or econometric methods. At the same time, when considering a restaurant's marketing strategy, it is also appropriate to consider more comprehensive economic and mathematical modeling options, especially optimization models, simulation models, fuzzy logic models, etc.

Developing a marketing strategy for a restaurant business is quite a complex task from a decision-making point of view, as different criteria and constraints, different situations in which rational (suboptimal) or optimal decisions have to be made, etc. have to be taken into account.

Marketing strategies should be developed taking into account different scenarios, which allows the formulation of some criteria and restrictions necessary for the use of certain methods of economic and mathematical modeling. At the same time, marketing strategies developed taking into account the results of economic and mathematical modeling allow for a more comprehensive analysis of possible solutions and the selection of the best ones.

Aims and purpose of the study

The aim of this study is to develop a set of economic and mathematical models for the formation of a marketing strategy and marketing plan using the example of a small business in the restaurant industry.

Most important results

Let us consider the marketing strategy for a small restaurant, taking into account the application of the economic and mathematical models developed by the authors. Based on the method of hierarchical analysis, a hierarchical model was created in which weighting coefficients (parameters) for the UFRS function were determined.

The utility function for the choice of restaurant in terms of consumer preferences is given as follows:

$$UFRS = U = x_1^{a1} \cdot x_2^{a2} \cdot x_3^{a3} \cdot x_4^{a4} \cdot x_5^{a5} \cdot x_6^{a6} \cdot x_7^{a7} \cdot x_8^{a8} ,$$

wherex_i are the entry elements in the hierarchy analysis model anda_i are the weighting factors (priority vector values) that influence the UFRS target.

At , these arex_1= PR(price);x_2= MPAY(payment method: cash, credit card, online);x_3= ASB (product range);x_4= INGQ (ingredient quality);x_5= PTWF (takeaway option);x_6= PSZ(portion size);x_7= ADV(advertising);x_8= QSRV (service quality). The corresponding weighting factors are:$a_1 =$ 0.2846 ; ; ; ; ; ; ; ; ; . $a_2 = 0.2352 a_3 = 0.1303 a_4 =$ 0.1233 $a_5 = 0.0989 a_6 = 0.0543 a_7 = 0.0469 a_8 = 0.0262$

The elements of the initial level are represented as variables that take values from 1 to 10. At the same time, both the consumer and the owners/managers of the restaurant can subjectively assess the values of these variables, so that fuzzy sets and fuzzy logic can be used in the extended version of the model to determine the values of the required variables.

The values for the entry elements in the hierarchy analysis model are on a scale of 1 to 10, taking into account the following rules: forx_1 , "1" means the highest price level, "5" the average price level and "10" the lowest price level; forx_2 , "1" means that only one payment method is available, "5" means that several payment options are available and "10" means that a wide variety of payment methods (cash, credit or debit cards, checks, online payment, club cards, bonuses, etc.) are available; for , "1" means that the selection of food and drinks on the menu is very small and "10" means that the restaurant has a very large selection of food and drinks.$x_6 x_7 x_8$Forx_3 , "1" means that the selection of food and drinks on the menu is very small and "10" means that the restaurant has a very large selection of food and drinks; forx_4 , "1" means that the quality of the ingredients used to prepare the food and drinks is low and "10" means that the quality of the ingredients used is very high; forx_5 , "1" means that it is not possible to order take-away food or drinks and "10" means that it is possible to order take-away food and drinks,

The utility function$UFRS = U$ can act as an objective function in an optimization problem, i.e. the goal of the restaurant is to maximize the value of the utility function, taking into account the available constraints in terms of price level, material, financial and human resources.

The function $UFRS = U$ is continuous under the condition of continuous values of the variables and assumes positive values that are greater than 0 but less than 10, as the sum of the parameters of this non-linear function $UFRS = U$ is equal to 1 and the values of the elements of the output level do not exceed 10 on the given scale.

As the function $UFRS = U$ is non-linear (step-shaped), it can be transformed into a linear form:

$lgU = a_1 \cdot lgx_1 + a_2 \cdot lgx_2 + a_3 \cdot lgx_3 + a_4 \cdot lgx_4 + a_5 \cdot lgx_5 + a_6 \cdot lgx_6 + a_7 \cdot lgx_7 + a_8 \cdot lgx_8$

(1)
Then the target function is .$F = lgU \to max$
To simplify the model, we are introducing new designations: $z_i = lgx_i$,
then the target function $F = \sum_{i=1}^{8} a_i \cdot z_i \to max$.

Next, we formulate boundary conditions for the solution of the optimization problem:

- Demand restrictions;
- Restrictions on the budget for advertising the restaurant and attracting new customers;
- Restrictions on the values of the entry elements that imply requirements for the use of the minimum and maximum capabilities of the restaurant.

The total number of visits per month does not exceed 500, i.e. $D \leq 500$. The total number of restaurant visits is made up of a constant part (demand does not depend on price and other factors) and a variable part (demand depends on price, advertising and quality of service).
The following theoretical function was used to model this variable part, i.e. the additional demand:

$D = 0.003617 \cdot 4^{0.5 \cdot Pl} \cdot 3^{0.3 \cdot ADV} \cdot 2^{0.2 \cdot QSRV}$, (2)

where D - number of visits by visitors per month, ,$P_l = 11 - PP$ - rating of the price level for the main course on a scale of 1 to 10 (1 - very high prices; 10 - very low prices), ADV - level of restaurant advertising, $QSRV$ - level of service quality.

The dependence of the additional demand D on the level of P_l under the condition of fixed values of $ADV = 10$ and $QSRV = 7$ is shown in Fig. 1.

Figure 1: Dependence of demand in the restaurant on the price level for the main course(s)
Source: Authors' calculations

If the price level of the main course(s) in a restaurant increases, the number of customer visits decreases according to the law shown in Figure 1.

In order to better analyze the characteristics of demand dependence on the price level, it is useful to determine the logarithms of the values of the demand function (Fig. 2).

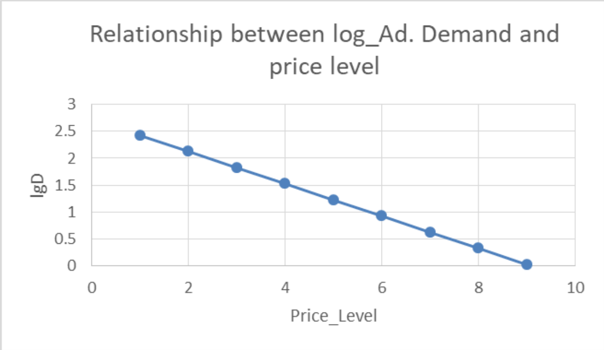

Fig. 2: Dependence of the values of the logarithms of demand in the restaurant on the price level for the main course(s)
Source: Authors' calculations

By logarithmizing the demand function, we obtain a linear function that can be used to form constraints in the optimization model:
$L = lgD = lg0.003617 + 0.5 \cdot Pl \cdot lg4 + 0.3 \cdot ADV \cdot lg3 + 0.2 \cdot QSRV \cdot lg2$, (3)
$L \leq lg500$.

Let's formulate a restriction on the budget used to stimulate demand in a restaurant.

We will use the following expression for the restriction:
$B = n \cdot (c_2 \cdot z_2 + c_3 \cdot z_3 + c_4 \cdot z_4 + c_5 \cdot z_5 + c_6 \cdot z_6 + c_7 \cdot z_7 + c_8 \cdot z_8)$, (4)
whereby

B - Budget value (EUR), n - number of visitor visits, c_i - unit costs (EUR) required to increase the value of z_i by one. Let's assume that when calculating the budget value, the number of visitor visits $n = 400$ and the budget value B can vary between 400 and 1200 euros.

$B = 400 \cdot (0.5 \cdot z_2 + 1 \cdot z_3 + 0.6 \cdot z_4 + 0.2 \cdot z_5 + 0.15 \cdot z_6 + 0.15 \cdot z_7 + 0.2 \cdot z_8)$, (5)

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Then $b = \frac{1}{n} \cdot B$, where b is the restaurant's advertising budget per 1 consumer.

Additional restrictions:
$3 \leq x_1 \leq 7$; ; ;$1 \leq x_2 \leq 10$ $5 \leq x_3 \leq 6$$5 \leq x_4 \leq 10$; (6)
$4 \leq x_5 \leq 10$; ; ;$4 \leq x_6 \leq 8$$2 \leq x_7 \leq 10$$5 \leq x_8 \leq 7$
$x_1^3 \cdot x_2^{0.25} \cdot x_3^{0.75} \cdot x_4^1 \cdot x_5^{0.25} \cdot x_6^{0.75} \cdot x_7^1 x_8^1 = 480.$

After logarithmization, let's move on to the variables used in the optimization model.
The result is:
$lg3 \leq z_1 \leq lg7$; ; ;$lg1 \leq z_2 \leq lg10$ $lg5 \leq z_3 \leq lg6$$lg5 \leq z_4 \leq lg10$; (7)
$lg4 \leq z_5 \leq lg10$; ; ;$lg4 \leq z_6 \leq lg8$$lg2 \leq z_7 \leq lg10$$lg5 \leq z_8 \leq lg7$
$3 \cdot z_1 + 0.25 \cdot z_2 + 0.75 \cdot z_3 + z_4 + 0.25 \cdot z_5 + 0.75 \cdot z_6 + z_7 + z_8 = lg480.$

So let's formulate the optimization problem:

$$F = 0.2846 \cdot z_1 + 0.2352 \cdot z_2 + 0.1303 \cdot z_3 + 0.1233 \cdot z_4 + 0.0989 \cdot z_5 + 0.0543 \cdot z_6 +$$

$$+ 0.0469 \cdot z_7 + 0.0262 \cdot z_8 \rightarrow max$$
(8)

with restrictions:
$0 \leq lg0.003617 + 0.5 \cdot z_1 \cdot lg4 + 0.3 \cdot z_7 \cdot lg3 + 0.2 \cdot z_8 \cdot lg2 \leq lg500$ (9)

$$1 \leq 0.5 \cdot z_2 + 1 \cdot z_3 + 0.6 \cdot z_4 + 0.2 \cdot z_5 + 0.15 \cdot z_6 + 0.15 \cdot z_7 + 0.2 \cdot z_8 \leq 3$$

$lg3 \leq z_1 \leq lg7$; ;$lg1 \leq z_2 \leq lg10$ $lg5 \leq z_3 \leq lg6$;$lg5 \leq z_4 \leq lg10$;

$lg4 \leq z_5 \leq lg10$; ;;$lg4 \leq z_6 \leq lg8$$lg2 \leq z_7 \leq lg10$$lg5 \leq z_8 \leq lg7$

$$3 \cdot z_1 + 0.25 \cdot z_2 + 0.75 \cdot z_3 + z_4 + 0.25 \cdot z_5 + 0.75 \cdot z_6 + z_7 + z_8 = lg480$$

The solver in Excel was used to solve the optimization problem and the following optimal values were determined:
z_1 =0.845098; 1; ; ; ; ;$z_2 = z_3 = 0{,}778151 z_4 = 1 z_5 = 1 z_6 = 0{,}90309 z_7 = 1 z_8 = 0$; ;,845098.

The value of the target function is . $F_{opt} = 0{,}917387$
For the optimum solution, we obtain the values: $L = 1.5183642$
and $b = 2.532634$.

We proceed to the initial variables and obtain the optimal values for the problem of forming the optimal marketing strategy of the restaurant under the given conditions.

These values are as follows:
$x_1 = 7$;$x_2 = 10$; ; ; ; ; ;$x_3 = 6 x_4 = 10 x_5 = 10 x_6 = 8 x_7 = 10 x_8 =$;7.

The value of the target function is $U_{opt} = 8.267751$.

The value of the additional demand resulting from the implementation of the optimal marketing strategy is $D = 10^{1{,}5183642} = 32.98863$. ≈ 33

The budget for 400 visitor visits amounts to 1013,054 euros and makes it possible to attract 33 new visitors based on positive feedback and recommendations from regular guests. In other words, the advertising leads to an increase in visitor numbers of 8.25%.

Let's look at the dependence of additional demand on the price level for the main course(s) and on different levels of service quality (Fig. 3).

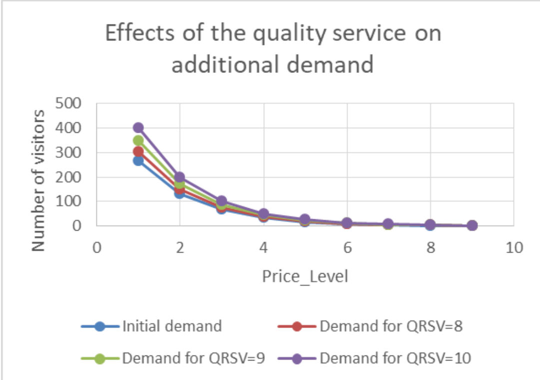

Figure 3: Dependence of demand in the restaurant on the price level for the main course(s) and on the quality of service

Source: Authors' calculations

Fig. 3 shows that when the quality of service in the restaurant improves, additional demand (the number of visitors) increases, with the greatest effect being observed at lower price levels for the main course(s). At the same time, the impact of service quality on additional demand in the restaurant is much lower at high price levels.

The dependence of the logarithms of the values of the additional demand for services in the restaurant on the level of prices and the quality of the services is shown in Figure 4. 4.

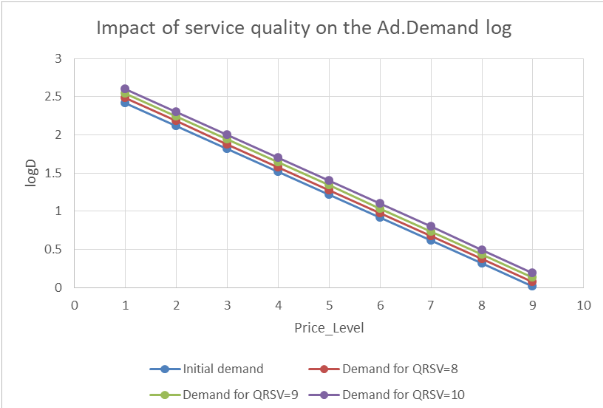

Fig. 4: Dependence of the values of the logarithms of demand in the restaurant on the price of the main course(s) and the level of service quality

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Source: Authors' calculations

As a result of solving the optimization problem (8) - (9), the optimal values of the entry elements for the initial UFRS utility function were determined, with elements such as:$x_2 = 10$; ; ;$x_4 = 10x_5 = 10x_7 = 10$ assuming the maximum possible values.

Particular attention should be paid to the optimal distribution of the advertising budget with regard to the choice of advertising media. Different generations of consumers prefer different social media and advertising methods. The older and middle generations focus on traditional advertising media through outdoor advertising (posters, TV commercials, leaflets and brochures), while the younger generation mainly relies on advertising on social networks that are popular with young people, such as Instagram, Tik-Tok, X, etc.

Improving service quality is also an important stimulus for demand for restaurant services, with particular attention being paid to the relationship between "price" and "quality", as more demanding consumers are willing to pay higher prices for the main dishes in the restaurant range, but also demand a higher quality of service.

Discussion and conclusions

The economic and mathematical models developed by the authors for the development of a marketing strategy and marketing plan for a small business in the hospitality industry make it possible to analyze various acceptable solutions and select the best ones. In the future, it is possible to improve these models, change the constraints and the objective function, parameter values, analyze the stability of the solution, apply the obtained solutions to other related problems, for example, the choice of pricing strategy, break-even analysis, the inclusion of seasonal factors in the demand function, the peculiarities of the behavior of various consumer groups in connection with modern trends in food culture, the study of demand for various dishes in the assortment of the restaurant menu, the formation of customer loyalty programs, the study of the impact

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