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Modeling the Processes of Managing the Advertising Budget of an Electronic Trading Platform

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Abstract. The paper presents the possibilities of using system-dynamic modeling to manage the advertising budget of an electronic trading platform. A model has been developed and its mathematical description is given. Computer experiments have been carried out corresponding to various configurations of the advertising budget (distribution between different target groups) with the calculation of such efficiency indicators as profitability, total costs due to irrational advertising costs, and the cost of attracting one client.

INTRODUCTION

In connection with the development of information technologies, there is a tendency to increase the number of electronic trading platforms (ETP), which are complex systems, in the structure of which it is possible to combine two or more interested parties using one information resource. On the one hand, these are sellers who want to increase sales, and on the other hand, there are buyers who are looking for goods and services that meet their needs.

ETP advertising has one feature [1] associated with the need to attract two different categories of users - buyers and sellers. The efficiency of the ETP depends on the balance of these two groups. Such situations, when a buyer cannot find the desired product due to a poor assortment, or a seller cannot sell his product due to low traffic, negatively affect the user experience of clients. This raises the dilemma of allocating funds between the costs of attracting buyers and sellers. The more advertising costs to buyers, the more potential customers can be attracted to sellers, and vice versa. It is necessary to determine what the ratio of costs between the specified groups should be in order to maximize the profit and minimize the cost of attracting one client. The most appropriate tool for solving such problems is a system-dynamic method [2 - 5]. We will use it to develop a simulation model for managing the advertising budget of the ETP and conduct experiments aimed at determining the optimal budget allocation.

THEORETICAL BACKGROUND

This paper considers the adaptation of the Internet trade management model described in the work of Lichtenstein and Mardakhaev [6] for the case of an electronic trading platform. Structurally, the model is divided into several blocks, each of which encapsulates a certain logic of the model's functioning. The main elements of any system-dynamic model are levels, paces and auxiliary variables [7].

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Since it is clear from the name of the method that it is possible to track the operation of the model in dynamics, it is necessary to make an important note about the simulation time [8]. Let us assume that time intervals reflect processes fixed in time and introduce the following notation:

$t = t_0, t_0 + 1, \dots, t_k$ - period index (fast time - 1 period, modeling step - 1 month);

$t_0 + 1 = \tau$ for equal time intervals; t_k - planning horizon is adopted 36 months.

Block 1. Financial result. The financial result of the enterprise is an accumulator, which is increased by income from successful transactions and reduced by fixed and variable costs, presented for simplicity in our model only by the advertising budget:

$$balans\ (t) = \int_{t_0}^{t} (income(\tau) - cost(\tau) - adBudget(\tau))d\tau + \ balans(t_0), t = \ \overline{t_0 \dots t_k} \tag{1}$$

where $\mathrm{income}(\tau)$ - enterprise income for the current period; $\mathrm{cost}(\tau)$ - fixed costs of the enterprise for the current period; $\mathrm{adBudget}(\tau)$ - the company's advertising budget for the current period.

The equation for the pace of income is given in block 7 "Calculation of income", since it depends on many other elements. The rate of advertising spending is governed by several conditions that determine the volume of advertising costs, depending on the amount of income and the current balance of the enterprise, and the moment when advertising costs stop. For simplicity, the rate of fixed costs in this model is unchanged, its value is taken from the current indicators of the enterprise:

$$cost(t) = 250\ 000 \tag{2}$$

Block 2. Distribution of the advertising budget. In this block, the advertising budget funds are distributed into two parts: to attract buyers (Wbuyer) and sellers (Wseller) in a ratio that is regulated by the coefficient B_{buyer}.

Block 3. Converting the advertising budget into buyers. This block implements the process of converting funds allocated for attracting customers into views, then visits, and finally into buyers, described in the mathematical model. Accordingly, this block contains the following variables. Views during the simulation period:

$$views\ (t) = \ FLOOR\left(\frac{Wbuyer(t)}{Wview}\right) \tag{3}$$

where floor - standard rounding function for the argument; $Wbuyer(t)$ - funds allocated for attracting buyers at time t; $Wview$ - the cost of one ad view.

Visits during the simulation period:

$$visits\ (t) = \ FLOOR(views(t) * CTR * correctKoff) \tag{4}$$

where floor - standard rounding function for the argument; $views(t)$ - number of views at a time t; CTR - click-through rate, $correctKoff$ - correction factor.

When the volume of the advertising budget and the number of visitors grows, this process passes the saturation point, when further advertising costs do not bring new buyers, the coefficient of the unit budget costs per one attracted buyer begins to grow, and the total attendance falls [9].

Number of buyers for the period:

$$buyers\ (t) = \ FLOOR(visits(t) * Pbuyer) \tag{5}$$

where floor - standard rounding function for the argument; $visits(t)$ - number of visitors at a time t; $Pbuyer$ - the likelihood of a customer making a purchase.

Block 4. Calculation of the number of buyers who canceled transactions. This block calculates the number of buyers who, for various reasons, can refuse the deal, as well as the costs arising from these refusals. Three types of refusals were identified: before buying ($buyers$Refusal), after placing a deal ($buyers$Order) and returning goods ($buyers$Returned), each of which has its own probability. In addition, a random component has been introduced into the equations, depending on the amount of funds allocated to attract buyers.

$$buyers\mathrm{Refusal}(t) = FLOOR(\ \mathrm{Prefusal} * \ buyers(t) * randomSellerShape(t)) \tag{6}$$

$$buyers\mathrm{Order}(t) = FLOOR(Porder * \ buyers(t) * randomSellerShape(\mathrm{t})) \tag{7}$$

$$buyers\mathrm{Returned}(t) = FLOOR(\mathrm{Preturned} * buyers(t) * randomSellerShape(t)) \tag{8}$$

Block 5. Calculation of auxiliary performance indicators. This block contains calculations of six auxiliary parameters required to simplify the definition of other variables.

Block 6. Calculation of the main performance indicator. This block presents the calculation of the total cost indicator due to the non-optimal distribution of the advertising budget:

$$FCO(t) = Buyers(t)_{total} * (CPB(t) + FO) + OC(t) + RC(t) \quad (9)$$

where $Buyers(t)_{total}$ - the total number of buyers who cancel the deal; $CPB(t)$ - cost of attracting one customer; FO - potential income from a successful deal; $OC(t)$ - losses from transactions that were then canceled by the buyer; $RC(t)$ - shipping losses for items that were returned by the buyer.

The indicator shows the total costs due to the excessive advertising budget for attracting buyers. These costs include: the cost of attracting buyers, who subsequently: refused to buy because of the small assortment; abandoned the deal by completing it; returned the item after purchase. With optimal budget management, these funds could be be used to attract new sellers who could provide wider assortment.

Block 7. Calculation of the company's income. This block calculates the company's income for the current period. In the formation of income, both buyers attracted by advertising and a certain percentage of repeat purchases are involved.

Let some of the buyers who have successfully made a purchase through the ETP stay every period and sometimes make repeated orders. To estimate this amount, let's introduce the level:

$$\text{ClientBuyers}\ (t) = \int_{t_0}^{t} (\text{registrationRate}(\tau) - outFlow(\tau))d\tau + \text{ClientBuyers}\ (t_0)\,, t = \overline{t_0 \dots t_k} \quad (10)$$

where $\text{registarationRate}(\tau)$ - number of customers who became regular for the current period; $outFlow(\tau)$ - outflow of regular customers for a given period;

$\text{ClientBuyers}\ (t_0)$ - initial number of regular customers.

The flow of new customers who have become regular customers is determined as follows:

$$\text{registrationRate}(t) = FLOOR(buyers(t) - BuyersTotal(t)) \quad (11)$$

where $buyers(t) - BuyersTotal(t)$ - the number of buyers in the current period who actually made an order.

The outflow of regular customers for a given period is determined as follows:

$$\text{outFlow}(t) = FLOOR(ClientBuyers(t) * randomBuyerShape(t)) \quad (12)$$

where $randomBuyerShape$ - a correction factor that takes into account the size of the advertising budget and is normally distributed on the estimate of this budget.

Variable that calculates the company's income for the current period:

$$\text{income}(t) = IPO * (buyers(t) - BuyersTotal(t) \ + \ ClientBuyers(t) * 0{,}25) \quad (13)$$

Block 8. Calculation of statistical indicators. The block includes the necessary calculations to obtain indicators by which one can evaluate the work: net profit; the total number of buyers who abandoned the deal; an indicator of the effectiveness of advertising, reflecting the total costs due to irrational redistribution of funds. Additionally, for each indicator, its average value is calculated.

SOME RESULTS

Based on the analysis of the simulation results, it was concluded that an increase of the budget leads to a decrease of the correction coefficient (correctKoff), which characterizes the degree of saturation of society with information, that is, the effectiveness of advertising falls and attracting buyers to the trading platform become more expensive (Fig. 1). From the analysis of the main indicators, the following pattern can be obtained: with an increase in the share of the budget, the average profit also grows, but starting with $B_{buyer} > 0{,}5$ this growth is slowing down. Indicators of "bad" buyers and total costs grow linearly with growth B_{buyer}. Figure 2 shows the results of one of the experiments.

CONCLUSION

The paper proposes a system-dynamic simulation model for managing the advertising budget of an ETP, which allows, based on the change in the shares of the advertising budget to attract buyers and sellers, to determine the most favorable conditions, assessing the costs of oversaturation with advertising information. Achievement of optimal values of the main indicators (maximum profit and minimum costs for attracting one buyer) occurs when the value of the share of funds allocated to attract buyers is 50 ± 5%. A further increase in this indicator leads to an increase in costs; more funds will be spent on attracting one new buyer, and profit growth will be insignificant.

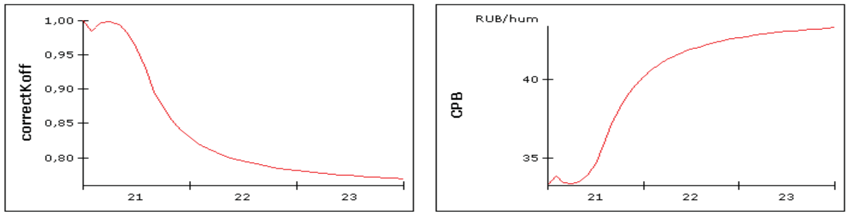

FIGURE 1. Chart of changes in indicators: correction factor (correctKoff) and the cost of attracting one buyer to the site (CPB).

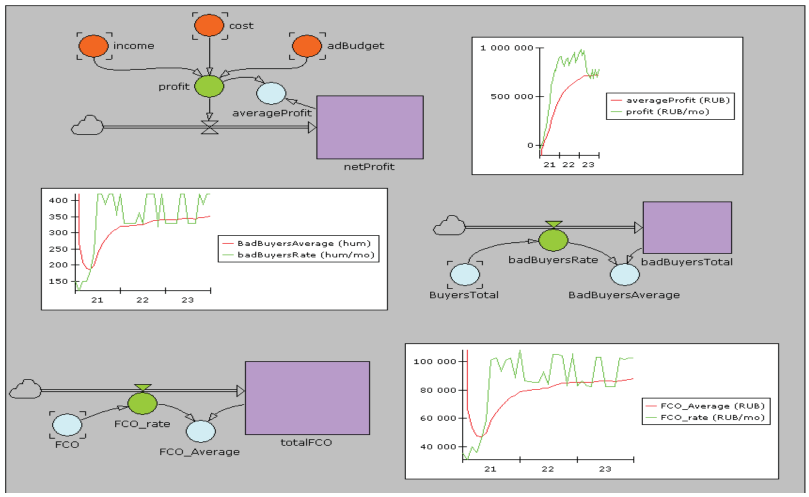

FIGURE 2. Statistical block of the model with simulation results.

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