Implementation of Manufacturer and Reseller Interaction Models, Taking Into Account Advertising Costs

Tetiana Bludova, Nataliya Danylyuk, Oleksandr Dyma, Olena Kachan, Olena Horokhova

Abstract.* Establishing effective cooperation between the manufacturer and reseller as vertical marketing channel participants implies the effective mechanism for the development of the main strategies of their business behaviour, such as price and expenditure forming for the joint promotion of the product. This provides the manufacturer and reseller the ability to select the most appropriate business game scenarios to maximize their profits in the short and long-term perspectives. This issue is relevant in the practice of distribution channels functioning. The purpose of the study is defining the optimal parameters values of expenditure function reaction for the compatible advertising, which will help to maximize the profits of both distribution channel participants. The research takes into account the statistical analysis of empirical data, in particular, data on average monthly sales volumes, as well as retail price for the unit of the product of the manufacturer enterprise. Besides, the paper presents a numerical experiment on the possible values of the advertisement expenditures parameters' function, calculated on the basis of effectively selected range and step change. It was mathematically substantiated and defined the solutions of Stackelberg's business game, which implies functioning of the manufacturer equilibrium. A numerical experiment was conducted to maximize the possibilities of the manufacturer's profitability features, reseller and marketing channel from the point of pricing strategies formation, and expenditure strategies for joint advertising of the both participants of the goods turnover channel. Stakelberg's variant of a business game is found to be optimal for the manufacturer, in which the percentage of its participation in the reseller's expenditures on the joint advertising is non-zero. The obtained results can be the initial information base to form recommendations on possibilities of Stakelberg's business game application in comparison with other variants of theoretical and game models of marketing channels' participants interaction.

***Keywords:* Stackelberg equilibrium, function of consumer demand, strategy of business behaviour, transfer price, retail price, joint advertising.**

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I. INTRODUCTION

The effective functioning of the market channel means to develop profitable relationship between its participants, which requires making appropriate management decisions on implementation of price and expenditure policy in order to achieve long-term profit maximization. In this regard, the importance of cooperation system uniqueness between enterprises – participants of market channels are increasing. It is caused by the peculiarities of hierarchical channel of goods turnover with defined authority relationship and rules of business game.

Theoretical knowledge and practical international experience of marketing channels functioning, in particular vertical ones, give the opportunity to define the concept of joint costs on the advertisement, which represent different options of cooperation between the manufacturer and reseller on determining the share of each other's corresponding expenditures during the product promotion process in the distribution channel. Thus, advertisement strategies of enterprises – participants of vertical marketing channel are taken from the point of managerial decisions on determining the amount (percentage) of costs on joint product advertising as the most effective from practical point of view approach to determine stimuli of manufacturer and reseller sale policy.

Advertising expenditures as an integral part of the enterprise advertising budget development form calculation base of the total amount of the advertising allocations, that are further taken into account while forming final financial results of the manufacturer as well as the reseller, that interact in the market channel.

In the process of cooperation of the both parties of the agreement it is often beneficial to collaborate in the direction of planning a part of the expenditures, which is reflected in the system of bonuses on advertisement, price discounts and rewards. This collaboration of the manufacturer and the reseller is about defining the amount of joint expenditures on the advertisement, that are treated as the part of the sum costs, which the participants of the market channel are ready to pay in the process of product promotion to the final consumers. In this case, parts of the manufacturer and reseller expenditures on the joint product promotion can vary depending on the redistribution of the authority relationship in the channel of goods turnover, which leads to the leadership position of one of them.

Thus, models of relationship of the manufacturer enterprise and retail sales enterprise (reseller) reflect the dynamic strategic cooperation of the vertical marketing channel participants and lead to finding their equal price strategies, as well as strategies of forming expenditures on the joint advertising product, which in its turn influences the formation of the volumes of sales and incomes (profits).

The study focuses on a two-stage, non-dynamic game between producer and intermediary on the implementation of pricing strategies and a cooperation agreement in the form of cost sharing for compatible product advertising in order to maximize the revenue of participants in the commodity channel. Co-advertising is a key factor in influencing the level of consumer demand for a product, since its use involves considerable leeway for both the manufacturer and the intermediary to determine the advertising budget and advertising plan.

The interaction of the manufacturer and the intermediary, which spend the cost of compatible advertising, is specific and involves the manufacturer's involvement in the advertising of the intermediary. In the context of this, scholars Xie, J., Neyret, A. [14], Xie, J., Wei, J.C.[15], as well as Bergen, M. & John, G. [1] define the cost of compatible advertising as the coverage ratio (engagement ratio) of all or part of the costs of the intermediary manufacturer. Researchers Tsou, Ch.-S., Fang et al. [13], Jorgensen, S., Taboubi, S., Zaccour, G. [6], Huang, Z., Li, S.X. [4], He, Y., Liu, Zh., Usman, Kh. [3], Li, S. X., Huang, Z., et al.[10] consider compatible advertising as a co-ordinating mechanism for cost-sharing between the manufacturer and the intermediary to promote the product in the distribution channel, which improves product quality, reduces supply and cost risks, improves information collection and profit sharing.

Determination of the features of the formation of the consumer demand function is based on static, one-period models, which allow to study in detail the mutual influence of the main business strategies in order to avoid conflicts in the commodity movement channel. The substantiation of expediency of using static models is given in the works of foreign scientists Bergen, M. & John, G. [1], Karray, S., Zaccour, G. [8] and Kim, SY, Staelin, R. [9], in numbers to investigate the structure of power in marketing channels dominated by one participant, as noted by Huang, Z., Li, S.X [4] and Li, S. X., Huang, Z. and others [10].

Authors Solanki, K., Gor, R. [11], Thompson, G.L., Teng, J.T. [12], Jorgensen, S., Zaccour, G. [6] consider the multiplicative function of consumer demand, which is characterized by the complex influence of its components on the resultant indicator (profit). The main characteristics of this function are described in the works of Yue, J., Austin, J. and others[16], Xie, J., Wei, J.C. [15], Xie, J., Neyret, A. [14], and Li, S. X., Huang, Z., et al. [10]. In particular, Xie, J., Neyret, A. [14] discusses the function of consumer demand, which is mathematically represented as follows:

$$D(w,v,p_r) = h(p_r)\times G(w,v), \qquad (1)$$

where w – the cost of the intermediary for advertising; v – the manufacturer's costs for advertising (advertising investments in a brand or brand); p_r – retail price per unit of product; $h(p_r)$ - linear functional relationship between sales volume and unit price; $G(w,v)$ – Cost-response feature for compatible advertising.

Jorgensen, S., Sigué, S.-P., Zaccour, G. [5] present a descending function $h(p_r)$ as follows:

$$h(p_r) = a - b\cdot p_r,\ a,b\in R, \qquad (2)$$

where a,b are the parameters that are positive constants.

Xie, J., Neyret, A. [14] note that equation (2) can be considered as a linear linear regression equation with parameter estimates, in which the average value of the product demand is determined by the change in the retail price level per unit of product and random factors that influence the volume of demand.

Consider the cost-response function for compatible advertising $G(w,v)$, which depends on two variables. Huang, Z., Li, S.X. [4] proposed a mathematical notation of a function $G(w,v)$ in the form of:

$$G(w,v) = A - \frac{B}{w^{\alpha}\times v^{\beta}};\quad A,B,w,v>0,\quad \alpha,\beta\in(0;1), \qquad (3)$$

where A is the scattered asymptote of sales, the level of market saturation; B – estimation parameter; α,β – quasi-advertising elasticity respectively for the intermediary and the manufacturer.

$G(w,v)$ is a non-descending function of retail sales flexibility, which takes into account the opposite, but complementary advertising goals of the manufacturer and the intermediary, and in the complex describes the positive impact of compatible advertising costs on the final sales volume in the sales channel. The function $G(w,v)$ approaches the saturation level A, provided that at least one of the variables w,v goes to infinity. The value of the parameter, as noted by Yue, J., Austin, J. and others [16], reflects the impact of costs for compatible product advertising on expected market demand for the product. Given the features of functions (2) – (3), equation (1) can be represented as follows:

$$D(w,v,p_r) = (a-b\cdot p_r)\times\left(A-\frac{B}{w^{\alpha}\times v^{\beta}}\right); \qquad (4)$$

$$a,b>0,\ A,B,w,v>0,\ \alpha,\beta\in(0;1).$$

Consumer demand function (4) can be expressed in the light of pricing strategies as well as strategies for generating compatible advertising costs implemented by the manufacturer and intermediary in the marketing channel. Then the consumer demand function, which is also considered as a profit function, will have the following form:

a) for the manufacturer:

$$D(w,v,p_r) = (p_t - c)\cdot(a-b\cdot p_r)\cdot\left(A-\frac{B}{w^{\alpha}\cdot v^{\beta}}\right), \qquad (5)$$

b) for the mediator:

$$D(w,v,p_r) = (p_r - p_t - c_r)\cdot(a-b\cdot p_r)\cdot\left(A-\frac{B}{w^{\alpha}\cdot v^{\beta}}\right), \qquad (6)$$

where c – the cost of the product; p_t – transfer price per unit of product; c_r – the cost of the intermediary to sell the product unit.

The profit function of the manufacturer (5) takes into account the reduction of his profit by the amount of costs $(c_{am} \cdot w - v)$, where c_{am} is the percentage of the manufacturer's reimbursement of the intermediary's costs for compatible product advertising. Thus, the profit function (5) can be represented as follows:

$$\Pr_m = (p_t - c) \cdot (a - b \cdot p_r) \cdot (A - \frac{B}{w^{\alpha} \cdot v^{\beta}}) - (c_{am} \cdot w) - v, \quad (7)$$

At the same time, the profit function of the intermediary (6) takes into account the reduction of its profit by the amount of the cost of compatible advertising, which the manufacturer does not cover, so it has the following form:

$$\Pr_r = (p_r - p_t - c_r) \cdot (a - b \cdot p_r) \cdot (A - \frac{B}{w^{\alpha} \cdot v^{\beta}}) - (1 - c_{am}) \cdot w \cdot \quad (8)$$

By identifying the revenue and revenue generating features of the manufacturer and the intermediary in the commodity channel, you can determine the profit function of the entire marketing channel:

$$\Pr_{ch} = \Pr_m + \Pr_r = \quad (9)$$

$$= (a - b \cdot p_r) \cdot (A - \frac{B}{w^{\alpha} \cdot v^{\beta}}) \cdot (p_r - c - c_r) - w - v$$

In the process of dimensionlessness of the main constituent functions (7) – (9), for the purpose of numerical modeling, the following profit functions are obtained:

a) the manufacturer:

$$\Pr_m = p_t \cdot (1 - p_r) \cdot \left(\frac{A}{(B)^{\frac{1}{\alpha+\beta+1}}} - \frac{1}{w^{\alpha} \cdot v^{\beta}} \right) - c_{am} \cdot w - v \quad (10)$$

b) the reseller:

$$\Pr_r = (p_r - p_t) \cdot (1 - p_r) \cdot \left(\frac{A}{(B)^{\frac{1}{\alpha+\beta+1}}} - \frac{1}{w^{\alpha} \cdot v^{\beta}} \right) - (1 - c_{am}) \cdot w \quad (11)$$

c) marketing channel:

$$\Pr_{ch} = p_r \cdot (1 - p_r) \cdot \left(\frac{A}{(B)^{\frac{1}{\alpha+\beta+1}}} - \frac{1}{w^{\alpha} \cdot v^{\beta}} \right) - w - v \quad (12)$$

It should be noted that in the mathematical record of the profit functions (10) - (12) α, β are estimation parameters whose values change in the range (0; 1) with effectively chosen step $k = 0{,}1$.

Duffy, J. [2] states that the model of behavior of participants in a vertical marketing channel, involves taking into account the features of the business game itself, which is defined as a situation in which:

– there are two participants (players);
– each participant has the opportunity to choose several options for business behavior (game strategies);
– the strategies chosen by the players directly affect the outcome of the business game;
– every possible outcome of the game implies the existence of benefits for its participants.

Since the interaction of the manufacturer and the intermediary in the commodity movement channel is taken into account, the desire of each of them to maximize their own profit is projected to make rational decisions regarding possible joint interaction in order to achieve the optimum result of a business game. The effectiveness of the marketing channel is often viewed through the prism of redistribution of power relations among its participants, which from the standpoint of theoretical and game modeling means the possibility of building models of partial or complete leadership.

The study takes into account the game situation that embodies overall leadership, including the presence of a manufacturer's leadership position in defining business behavior strategies in the formation of profit functions. Such a business game involves forming the equilibrium of the manufacturer according to Stackelberg and satisfies the basic condition of correlation of price strategies of participants of the marketing channel:

$$1 - 2 \cdot p_r + p_t = 0 \Rightarrow p_r = \frac{1 + p_t}{2} \quad (13)$$

To find the solution to the game of Stackelberg, in which the producer occupies the position of leader and the reseller - the follower, we write the necessary condition for the existence of an extremum of the profit function of the producer (10):

$$\begin{cases} (\Pr_m)'_v = 0, \\ (\Pr_m)'_{c_{am}} = 0, \\ (\Pr_m)'_{p_t} = 0 \end{cases} \quad (14)$$

The partial derivative of the first order of the profit function of the manufacturer on the variable v is:

$$(\Pr_m)'_v = \frac{p_t}{2} \cdot (1 - p_t) \cdot \left[\frac{\beta}{\alpha+1} \cdot \left(\frac{\alpha}{4} \right)^{-\frac{\alpha}{\alpha+1}} \cdot (1 - c_{am})^{\frac{\alpha}{\alpha+1}} \cdot v^{-\frac{\alpha+\beta+1}{\alpha+1}} \cdot (1 - p_t)^{-\frac{2 \cdot \alpha}{\alpha+1}} \right] + \quad (15)$$

$$+ c_{am} \cdot \frac{\beta}{\alpha+1} \cdot \left(\frac{4}{\alpha} \cdot (1 - c_{am}) \right)^{-\frac{1}{\alpha+1}} \cdot (1 - p_t)^{\frac{2}{\alpha+1}} \cdot v^{-\frac{\alpha+\beta+1}{\alpha+1}} - 1$$

The partial derivative of the first order of the profit function of the manufacturer on the variable c_{am} is written as follows:

$$(\Pr_m)'_{c_{am}} = \frac{v^{-\frac{\beta}{\alpha+1}}}{\alpha+1} \cdot (1 - c_{am})^{-\frac{1}{\alpha+1}} \cdot \left(\frac{\alpha}{4} \right)^{\frac{1}{\alpha+1}} \cdot \quad (16)$$

$$\cdot (1 - p_t)^{\frac{2}{\alpha+1}} \cdot \left[\frac{2 \cdot p_t}{(1 - p_t)} - \left(\alpha + 1 + \frac{c_{am}}{1 - c_{am}} \right) \right]$$

Finding the partial derivative of the first order of the profit function of the manufacturer on a variable p_t leads to the function of the following form:

$$(\Pr_m)'_{p_t} = \frac{1}{2}\cdot(1-2\cdot p_t)\cdot\frac{A}{(B)^{\frac{1}{\alpha+\beta+1}}} - \frac{1}{2}\cdot\left(\frac{\alpha}{4}\right)^{-\frac{\alpha}{\alpha+1}}\cdot \tag{17}$$

$$\cdot v^{-\frac{\beta}{\alpha+1}}\cdot(1-c_{am})^{\frac{\alpha}{\alpha+1}}\cdot(1-p_t)^{\frac{1-\alpha}{\alpha+1}}\cdot$$

$$\cdot\left(\frac{\alpha+1-2\cdot p_t}{(\alpha+1)\cdot(1-p_t)} - \frac{c_{am}\cdot\alpha}{(1-c_{am})\cdot(\alpha+1)}\right).$$

Therefore, finding solutions to the system of equations (14) will be reduced to finding the values of the parameters v, c_{am} expressed in p_t. Equating the partial derivative (16) of the profit function of the manufacturer to zero, we find the value of the parameter: $c_{am} = \dfrac{p_t\cdot(3+\alpha)-(\alpha+1)}{p_t\cdot(2+\alpha)-\alpha}$.

Since c_{am} expresses the proportion of the intermediary's costs for compatible advertising of a product covered by the manufacturer, this value is integral, so it is advisable to consider the solutions to the following inequality:

$$c_{am}\ge 0 \Rightarrow \frac{p_t\cdot(3+\alpha)-(\alpha+1)}{p_t\cdot(2+\alpha)-\alpha}\ge 0\cdot \tag{18}$$

The inequality solution (18) can be represented as a system that reflects the dependence of the variable p_t on the parameter α at $c_{am}=0$ and the intervals of the allowed values p_t at $c_{am}>0$:

$$\begin{cases} p_t = \dfrac{1+\alpha}{3+\alpha}, \quad c_{am}=0, \\ 0<p_t<\dfrac{\alpha}{2+\alpha}\bigcup p_t>\dfrac{1+\alpha}{3+\alpha}, \quad c_{am}>0. \end{cases} \tag{19}$$

Consider the case where the parameter value $c_{am}=0$. Then the optimal value of the variable w, expressed through p_t, for this case, the formation of equilibrium of the producer according to Stackelberg is:

$$w^{S_T} = \left[\frac{\alpha}{4}\cdot\left(\frac{\alpha\cdot(\alpha+1)\cdot(1-p_t)}{2\cdot\beta\cdot p_t}\right)^{\beta}\cdot(1-p_t)^2\right]^{\frac{1}{\alpha+\beta+1}} \tag{20}$$

Taking into account equality (20), which expresses the costs of the intermediary for the joint promotion of the product in the channel of movement, the value of the corresponding costs of the manufacturer v is:

$$v^{S_T} = w^{S_T}\cdot\frac{2\cdot\beta\cdot p_t}{\alpha\cdot(\alpha+1)\cdot(1-p_t)} \tag{21}$$

Thus, the solution of the game Stackelberg, in which the manufacturer takes the position of leader and the reseller - the follower, at $c_{am}=0$, can be represented as a system of equations:

$$\begin{cases} c_{am}^{S_T}=0, \\ p_t^{S_T}=\dfrac{1+\alpha}{3+\alpha}, \\ p_r^{S_T}=\dfrac{2+\alpha}{3+\alpha}, \\ w^{S_T}=\left[\dfrac{\alpha}{(3+\alpha)^2}\cdot\left(\dfrac{\alpha}{\beta}\right)^{\beta}\right]^{\frac{1}{\alpha+\beta+1}}, \\ v^{S_T}=w^{S_T}\cdot\dfrac{\beta}{\alpha}. \end{cases} \tag{22}$$

If, $c_{am}>0$ in particular $c_{am}=\dfrac{p_t\cdot(3+\alpha)-(\alpha+1)}{p_t\cdot(2+\alpha)-\alpha}$, the value of the reseller's costs w is

$$w^{S_T} = \left(\frac{\alpha}{4}\cdot(1-p_t)\cdot(p_t\cdot(2+\alpha)-\alpha)\cdot\left(\frac{\alpha}{\beta}\right)^{\beta}\right)^{\frac{1}{\alpha+\beta+1}}, \tag{23}$$

and the manufacturer respectively:

$$v^{S_T} = \frac{\beta}{\alpha}\cdot w^{S_T} \tag{24}$$

Thus, the Stakelberg's game solution, in which the manufacturer is the leader and the reseller – the follower, if $c_{am}=\dfrac{p_t\cdot(3+\alpha)-(\alpha+1)}{p_t\cdot(2+\alpha)-\alpha}$, and given the intervals of admissible values for the variable p_t according to (19),

$$\begin{cases} c_{am}>0, \quad c_{am}=\dfrac{p_t\cdot(3+\alpha)-(\alpha+1)}{p_t\cdot(2+\alpha)-\alpha}, \\ 0<p_t<\dfrac{\alpha}{2+\alpha}\bigcup p_t>\dfrac{1+\alpha}{3+\alpha}, \\ p_r^{S_T}=\dfrac{1+p_t}{2}, \\ w^{S_T}=\left(\dfrac{\alpha}{4}\cdot(1-p_t)\cdot(p_t\cdot(2+\alpha)-\alpha)\cdot\left(\dfrac{\alpha}{\beta}\right)^{\beta}\right)^{\frac{1}{\alpha+\beta+1}}, \\ v^{S_T}=\dfrac{\beta}{\alpha}\cdot w^{S_T}. \end{cases} \tag{25}$$

Given that in (25) c_{am}, p_r, w, v are functions of p_t, it is necessary to find the value of a variable p_t that is optimal for the given game conditions and at the same time satisfies the conditions of inequalities of system (19). From the calculation of the partial derivative of the first order of the profit function of the manufacturer p_t on the variable given in (17), it can be seen that it is difficult to analytically find the value p_t by solving the equation $\dfrac{\partial \Pr_m}{\partial p_t}=0\cdot$

Therefore, in order to finally find the solutions of system (25), it is necessary to numerically simulate the outputs of the model of revenue generation model $\dfrac{A}{(B)^{\frac{1}{\alpha+\beta+1}}}, \alpha, \beta$ with an effectively chosen step k.

To perform a numerical experiment to determine the optimal parameter value ratios α, β, it is necessary to calculate the ratios of linear paired regression equation parameters a, b that depend on the components A, B of the calculated Stackelberg business game variants for the revenue generation models of the vertical marketing channel.

Let's make some assumptions about the values of the cost-response function for compatible advertising $G(w,v) = A - \frac{B}{w^{\alpha} \times v^{\beta}}$.

In particular:

1. For a manufacturing company, even a large advertising campaign cannot double its sales volume. Therefore, we can assume that the level of market saturation $A = 2$.

2. Generally, a manufacturer's promotional ad can increase its sales by no more than 50%. Therefore, we can assume that the parameter $\frac{B}{w^{\alpha} \cdot v^{\beta}} = \frac{1}{2}$, where $B = 0,5 \cdot w^{\alpha} \cdot v^{\beta}$.

The dimensionless values A, B for profit functions (10) - (12) depend on the values of the parameter estimates a, b and have the following form:

$$A = 2 \times \frac{a^2}{b}, \; B = 0,5 \times \frac{a^2}{b} \times w^{\alpha} \times v^{\beta}. \qquad (26)$$

Then the complex variable $\frac{A}{(B)^{\frac{1}{\alpha+\beta+1}}}$ can be represented as follows:

$$\frac{A}{(B)^{\frac{1}{\alpha+\beta+1}}} = A \times (B)^{-\frac{1}{\alpha+\beta+1}} = 2 \times \frac{a^2}{b} \times \left(0,5 \times \frac{a^2}{b} \times w^{\alpha} \times v^{\beta}\right)^{-\frac{1}{\alpha+\beta+1}}. \qquad (27)$$

In order to find the relationship $\frac{a^2}{b}$, it is worth examining the nature of the volume of demand for the unit price of the producer's product, taking into account the relationship between the transfer price p_t set by the manufacturer and the retail price p_r at which the intermediary offers the producer's product to the end consumer.

The calculation of linear regression parameters for a manufacturer's product requires the search and economic justification of the values of the regression equation parameters $Y = a + b \cdot X$. Analyzing the sample data by volume $n = 36$ allowed us to construct the following regression equation

$$Y = -0,0719193 \cdot X + 4057524,97, \qquad (28)$$

Table- I: Main characteristics numeric model pair linear regression $Y = a + b \cdot X$

Parameter estimates	Parameter Estimation b	Parameter Estimation a
	-0,0719193	4057524,97
The coefficient of determination R^2	0,95993257	6682,151268
F - Fisher criteria	814,569433	34

Thus, with a probability of making a mistake of 4%, it can be argued that the regression model (28) best describes the inverse relationship between the retail price of the product of the manufacturing enterprise and the volumes of its sale, and therefore is representative.

II. METHODOLOGY

The following methods were used in the simulation process: analytical analysis (when analyzing expert pairwise comparisons); probabilistic and statistical methods of analysis (to find the value of the probabilities of incompatible hypotheses of quantitative and qualitative measurement of the statistical probability of the relevant indicators of experimental events in the organization of reengineering); economic and mathematical modeling (when creating a model of enterprise reengineering in the context of global digitalization).

III. RESULTS

A further numerical experiment on the effect of compatible advertising costs on the revenue generation of vertical marketing channel participants is to investigate the possible relationships of parameter values α, β with the condition that $\alpha, \beta \in (0;1)$ and $\alpha, \beta \in R$.

In this case, for each variant of the model of the business game of Stakelberg two cases are considered: the magnitudes of profits are calculated provided that for each value α of the set $\alpha = \{0,1;\; 0,2;\; 0,3;\; 0,4;\; 0,5;\; 0,6;\; 0,7;\; 0,8;\; 0,9\}$ the parameter $\beta \in (0;1)$ and vice versa.

To provide practical guidance on the possibilities of adapting the Stakelberg business game model to the mechanism of interaction between the manufacturer and the intermediary in the channel of trade, we analyze the data in Table. 2.

They indicate that, with the increase of the parameter value $\beta \in (0;1)$, provided that $\alpha = 0,9$ the cost of intermediary w for compatible advertising exceeds the corresponding cost of the manufacturer v ($w > v$); and only if $\alpha = \beta = 0,9$ these costs are equivalent.

Table- II: Summary data on forming the equilibrium of the manufacturer according to Stackelberg for the products of the manufacturer at $c_{am}=0$, $\alpha=0{,}9$, $\beta\in(0;1)$

α	β	w	v	p_t	p_r	$\Pr_m$	$\Pr_r$	$\Pr_{ch}$
0,9	0,1	0,2715	0,0302	0,4872	0,7436	11450795,4	6026734,163	17477529,56
0,9	0,2	0,3003	0,0667	0,4872	0,7436	25040175,33	13179039,38	38219214,71
0,9	0,3	0,3213	0,1071	0,4872	0,7436	50239545,08	26441865,56	76681410,64
0,9	0,4	0,3368	0,1497	0,4872	0,7436	94027606,03	49488213,44	143515819,5
0,9	0,5	0,3480	0,1933	0,4872	0,7436	166021991,8	87379995,43	253401987,2
0,9	0,6	0,3557	0,2371	0,4872	0,7436	278913939,1	146796809,80	425710748,9
0,9	0,7	0,3607	0,2805	0,4872	0,7436	448833787,8	236228309,20	685062097
0,9	0,8	0,3634	0,3230	0,4872	0,7436	695628018,7	366120009,60	1061748028
0,9	0,9	0,3643	0,3643	0,4872	0,7436	1043034953	548965764,50	1592000717

Consider the case where for each value of a parameter β in the set $\beta=\{0{,}1;\ 0{,}2;\ 0{,}3;\ 0{,}4;\ 0{,}5;\ 0{,}6;\ 0{,}7;\ 0{,}8;\ 0{,}9\}$, the value of a parameter α that varies in the range $(0;1)$ is matched. To do this, we analyze the data in Table III.

They confirm that, for all $\alpha\in(0;1)$, $\beta=0{,}9$ except where $\alpha=\beta=0{,}9$ the cost of intermediary w for compatible advertising is less than the corresponding cost of the manufacturer v ($w<v$), which is not acceptable to the manufacturer's leader in the business game.

Table- III: Summary data on forming a producer equilibrium by Stackelberg for the manufacturer's products at $c_{am}=0$, $\beta=0{,}9$, $\alpha\in(0;1)$

α	β	w	v	p_t	p_r	$\Pr_m$	$\Pr_r$	$\Pr_{ch}$
0,1	0,9	0,0380	0,3416	0,3548	0,6774	9354683,455	8504257,959	17858941,41
0,2	0,9	0,0806	0,3625	0,3750	0,6875	21283074,11	17735895,32	39018969,43
0,3	0,9	0,1247	0,3740	0,3939	0,6970	44193789,65	33995222,97	78189012,61
0,4	0,9	0,1687	0,3795	0,4118	0,7059	85214837,53	60867741,19	146082578,7
0,5	0,9	0,2116	0,3808	0,4286	0,7143	154401264,1	102934176,1	257335440,2
0,6	0,9	0,2528	0,3792	0,4444	0,7222	265261977,1	165788735,7	431050712,8
0,7	0,9	0,2921	0,3756	0,4595	0,7297	435195065,6	255997097,4	691192163
0,8	0,9	0,3293	0,3705	0,4737	0,7368	685798632,3	380999240,0	1066797872

As can be seen from the table II and table III, if $\alpha=\beta=0{,}9$ the retail price $p_r=0{,}7436$ exceeds the transfer price $p_t=0{,}4872$, that is, the condition $p_r>p_t$ that satisfies the rules of the business game is fulfilled. Given that $p_r>p_t$, parameter values $\alpha=\beta=0{,}9$ are considered optimal in terms of generating costs for compatible product advertising, since costs $w=v$ are equivalent and profit functions maximized. In this case, the profit of the producer-leader $\Pr_m$ exceeds the value of profit of the intermediary-follower $\Pr_r$ almost twice, which indicates favorable opportunities for the producer to maximize his own profit.

In particular, graphically in Fig. 1 the model of profit of the producer ($\Pr_m$) is provided provided that the equilibrium of the producer according to Stackelberg is formed at $c_{am}=0$, $\alpha=0{,}9$, $\beta\in(0;1)$, in the form of a surface.

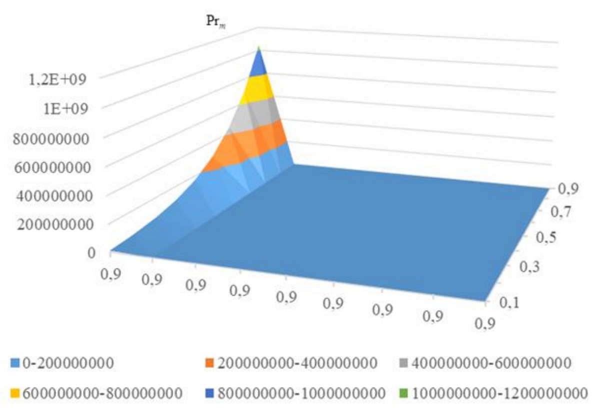

Fig. 1. Surface earnings manufacturer ($\Pr_m$) provided by the manufacturer formation Stackelberg uilibrium, $c_{am}=0$, $\alpha=0.9, \beta\in(0;1)$

The model also profit intermediary ($\Pr_r$) provided for the formation of equilibrium the manufacturer by Stackelberg at $c_{am} = 0$, $\beta = 0.9$, $\alpha \in (0;1)$ in the form of a surface (Fig.2).

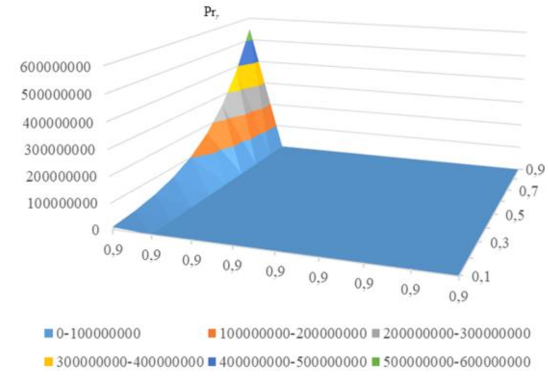

Fig. 2. The surface of the reseller's profit ($\Pr_r$) provided that the equilibrium of the manufacturer by Stackelberg is formed at $c_{am} = 0$, $\beta = 0{,}9$, $\alpha \in (0;1)$

In order to determine whether and to what extent the manufacturer's involvement in the intermediary's costs for compatible product advertising, it is worth examining the peculiarities of the equilibrium formation of the producer according to Stackelberg, which corresponds to the system of equations (25). The difference between this system and the system of equations (22) is that in order to calculate all the variable profit functions of the manufacturer, intermediary and marketing channel, in addition to finding the optimal parameter values α, β, it is necessary to estimate the intervals of allowable values for the transfer price p_t. To carry out a further numerical experiment, we restrict the set of inequalities $0 < p_t < \frac{\alpha}{2+\alpha} \bigcup p_t > \frac{1+\alpha}{3+\alpha}$, in particular part of it $p_t > \frac{1+\alpha}{3+\alpha}$, taking into account the interval length for the variable p_t formed in the left part of the set, and obtain:

$$0 < p_t < \frac{\alpha}{2+\alpha} \bigcup p_t > \frac{1+\alpha}{3+\alpha} \Rightarrow \qquad . \qquad (29)$$

$$0 < p_t < \frac{\alpha}{2+\alpha} \bigcup \frac{1+\alpha}{3+\alpha} < p_t < \left(\frac{1+\alpha}{3+\alpha} + \frac{\alpha}{2+\alpha}\right).$$

If $\beta = \{0{,}1;\ 0{,}2;\ 0{,}3;\ 0{,}4;\ 0{,}5;\ 0{,}6;\ 0{,}7;\ 0{,}8;\ 0{,}9\}$ and $\alpha \in (0;1)$ for each value β, then the value p_t, according to (29) depend on α, will go to the corresponding limit values, but will not reach them, since the inequalities in (29) are strict. Therefore, it is advisable to consider the discrete values of a variable p_t that satisfy the following conditions:

$$p_t \in \left(0; \frac{\alpha}{2+\alpha}\right) \bigcup p_t \in \left(\frac{1+\alpha}{3+\alpha}; \frac{2\cdot\alpha^2 + 6\cdot\alpha + 2}{\alpha^2 + 5\cdot\alpha + 6}\right). \qquad (30)$$

To refine the calculations, we choose two variable values p_t from each interval; to do this, suppose that an effective change step p_t is $l = \frac{\alpha}{2+\alpha}$. In the table IV shows the limit values and, based on the selected step l, the values of the variable p_t approximated to them.

Table- IV: The marginal and approximate values of the transfer price when forming a manufacturer equilibrium according to Stackelberg, provided that $c_{am} > 0$, $l = \frac{\alpha}{2+\alpha}$

values α	Limit values $p_t \in \left(0; \frac{\alpha}{2+\alpha}\right)$		Valid values $p_t \in \left(0; \frac{\alpha}{2+\alpha}\right)$		Limit values $p_t \in \left(\frac{1+\alpha}{3+\alpha}; \frac{2\cdot\alpha^2+6\cdot\alpha+2}{\alpha^2+5\cdot\alpha+6}\right)$		Valid values $p_t \in \left(\frac{1+\alpha}{3+\alpha}; \frac{2\cdot\alpha^2+6\cdot\alpha+2}{\alpha^2+5\cdot\alpha+6}\right)$	
	Lower boundary	The upper boundary			Lower boundary	The upper boundary		
0,1	0	0,0476	0,0159	0,0317	0,3548	0,4025	0,3707	0,3866
0,2	0	0,0909	0,0303	0,0606	0,3750	0,4659	0,4053	0,4356
0,3	0	0,1304	0,0435	0,0870	0,3939	0,5244	0,4374	0,4809
0,4	0	0,1667	0,0556	0,1111	0,4118	0,5784	0,4673	0,5229
0,5	0	0,2000	0,0667	0,1333	0,4286	0,6286	0,4952	0,5619
0,6	0	0,2308	0,0769	0,1538	0,4444	0,6752	0,5214	0,5983
0,7	0	0,2593	0,0864	0,1728	0,4595	0,7187	0,5459	0,6323
0,8	0	0,2857	0,0952	0,1905	0,4737	0,7594	0,5689	0,6642
0,9	0	0,3103	0,1034	0,2069	0,4872	0,7975	0,5906	0,6941

Since in order to find valid values for a numerical experiment c_{am} it is necessary to take into account the peculiarities of the parameter α change and the principle of calculation of the transfer price p_t, then further calculations are reduced to finding the acceptable values c_{am} within the defined intervals in (30) values. The results of the corresponding calculations are given in table V.

Table- V: Admissible values of the manufacturer's participation rate c_{am} in the cost of intermediary for compatible advertising and the retail price p_r when forming manufacturer equilibrium according to Stackelberg

Values α	Valid values c_{am} for the interval $\left(0;\frac{\alpha}{2+\alpha}\right)$		Valid values p_r for the interval $\left(0;\frac{\alpha}{2+\alpha}\right)$		Valid values c_{am} for the interval $\left(\frac{1+\alpha}{3+\alpha};\frac{2\cdot\alpha^2+6\cdot\alpha+2}{\alpha^2+5\cdot\alpha+6}\right)$		Valid values p_r for the interval $\left(\frac{1+\alpha}{3+\alpha};\frac{2\cdot\alpha^2+6\cdot\alpha+2}{\alpha^2+5\cdot\alpha+6}\right)$	
0,1	15,7619	30,0476	0,5079	0,5159	0,0725	0,1383	0,6854	0,6933
0,2	8,2727	15,0909	0,5152	0,5303	0,1402	0,2557	0,7027	0,7178
0,3	5,7826	10,1304	0,5217	0,5435	0,2032	0,3560	0,7187	0,7404
0,4	4,5417	7,6667	0,5278	0,5556	0,2618	0,4419	0,7337	0,7614
0,5	3,8000	6,2000	0,5333	0,5667	0,3161	0,5158	0,7476	0,7810
0,6	3,3077	5,2308	0,5385	0,5769	0,3665	0,5796	0,7607	0,7991
0,7	2,9577	4,5450	0,5432	0,5864	0,4132	0,6349	0,7729	0,8161
0,8	2,6964	4,0357	0,5476	0,5952	0,4564	0,6831	0,7845	0,8321
0,9	2,4943	3,6437	0,5517	0,6034	0,4964	0,7251	0,7953	0,8470

In the process of calculations, there was a practical need to introduce an additional constraint on variables w,v, which is to consider the values that are valid for them only in the interval $\left(\frac{1+\alpha}{3+\alpha};\frac{2\cdot\alpha^2+6\cdot\alpha+2}{\alpha^2+5\cdot\alpha+6}\right)$. This is due to the inability to calculate the corresponding approximate values w,v in the interval $\left(0;\frac{\alpha}{2+\alpha}\right)$, since numerical calculations lead to the calculation of mathematical expressions that are meaningless.

To perform a comprehensive causation analysis of profit maximization, we use the data in Table VI, which presents the results of calculations of the main components that form the strategies of business behavior of the manufacturer and the reseller in the process of their interaction, the result of which is the formation of the equilibrium of the manufacturer according to Stackelberg.

Table- VI: Summary data on forming a manufacturer equilibrium by Stackelberg for manufacturer's products at

$c_{am} > 0$, $\beta = 0{,}9$, $\alpha \in (0;1)$

α	β	w	v	p_t	p_r	c_{am}	$\Pr_m$	$\Pr_r$
0,1	0,9	0,0384	0,3459	0,3707	0,6854	0,0725	9472200,975	8039596,254
0,2	0,9	0,0826	0,3715	0,4053	0,7027	0,1402	21607435,79	15852184,41
0,3	0,9	0,1292	0,3876	0,4374	0,7187	0,2032	44675500,86	28729576,77
0,4	0,9	0,1765	0,3972	0,4673	0,7337	0,2618	85345283,23	48640843,36
0,5	0,9	0,2235	0,4023	0,4952	0,7476	0,3161	152631887,9	77783558,36
0,6	0,9	0,2694	0,4041	0,5214	0,7607	0,3665	258083895,3	118464738,9
0,7	0,9	0,3136	0,4032	0,5459	0,7729	0,4132	415812679,5	172958758,2
0,8	0,9	0,3560	0,4005	0,5689	0,7845	0,4564	642351688,2	243357908,3
0,9	0,9	0,3962	0,3962	0,5906	0,7953	0,4964	956349223,4	331429409

As can be seen from the table VI, the manufacturer's costs for compatible product advertising for each pair of values α,β, in addition $\alpha = \beta = 0{,}9$, exceed the corresponding costs of the intermediary, $v > w$. At the same time, profits in the commodity channel reach maximum values, provided that $\alpha = \beta = 0{,}9$, therefore, the specified pair of parameter values can be considered as optimal for the investigated case of Stackelberg's business game. If $\alpha = \{0{,}1;\ 0{,}2;\ 0{,}3;\ 0{,}4;\ 0{,}5;\ 0{,}6;\ 0{,}7;\ 0{,}8;\ 0{,}9\}$ and $\beta \in (0;1)$ for each value α, the revenue-generating channel revenue model is subject to change only in terms of the manufacturer's and reseller's costs w,v for compatible advertising. As in the previous case, there was a need to introduce an additional constraint on the variables w,v in the calculations, due to the inability to obtain numeric expressions with w,v mathematical meaning for the interval $\left(0;\frac{\alpha}{2+\alpha}\right)$.

We use the data in table VII, taking into account the pricing strategies of the manufacturer and the intermediary, as well as strategies for generating costs for compatible product advertising and are displayed in numerical calculations in the range of change of parameter values $\beta \in (0;1)$ at $\alpha = 0{,}9$. As can be seen from the data in table VII, the reseller's costs for compatible product advertising for each pair of values α, β, in addition $\alpha = \beta = 0{,}9$, exceed the corresponding costs of the manufacturer v, ie. $w > v$. As in the previous case, profits in the commodity channel reach maximum values at $\alpha = \beta = 0{,}9$.

Table- VII: Summary data on forming manufacturer equilibrium by Stackelberg for manufacturer's products at $c_{am} > 0$, $\alpha = 0{,}9$, $\beta \in (0;1)$

α	β	w	v	p_t	p_r	c_{am}	$\Pr_m$	$\Pr_r$
0,9	0,1	0,3054	0,0339	0,5906	0,7953	0,4964	10448836,76	3621116,244
0,9	0,2	0,3359	0,0746	0,5906	0,7953	0,4964	22852177,27	7919579,311
0,9	0,3	0,3576	0,1192	0,5906	0,7953	0,4964	45865814,7	15895113,85
0,9	0,4	0,3731	0,1658	0,5906	0,7953	0,4964	85885982,04	29764378,44
0,9	0,5	0,3838	0,2132	0,5906	0,7953	0,4964	151742597,3	52587441,98
0,9	0,6	0,3908	0,2605	0,5906	0,7953	0,4964	255108152	88409486,75
0,9	0,7	0,3948	0,3071	0,5906	0,7953	0,4964	410845233,2	142381244,7
0,9	0,8	0,3965	0,3524	0,5906	0,7953	0,4964	637274316,4	220851802,7
0,9	0,9	0,3962	0,3962	0,5906	0,7953	0,4964	956349223,4	331429409

In this case, the leader manufacturer's profit margin $\Pr_m$ exceeds the successor reseller's profit almost three times, which indicates that it is more favorable than $c_{am} = 0$ it is for the manufacturer to maximize his profit.

Excess of retail price p_r over transfer p_t, as can be seen from the tables VI and VII can be explained by the peculiarities of the interaction of the participants in the vertical marketing channel, when each of them tries to get the lowest possible level of profit, which is reflected in the increase of the price of the product during its movement in the distribution channel.

With formed pricing strategies of vertical marketing channel participants, their costs for compatible advertising are balanced against $\alpha = \beta = 0{,}9$, which has a positive effect on the activity of the manufacturer, as it encourages him to interact under the given conditions of the business game.

CONCLUSIONS

In each case, numerical modeling of Stackelberg's business game, which involves the formation of equilibrium of the manufacturer, led to the emergence of several options for maximizing the profits of the manufacturer, the reseller and the channel as a whole, depending on the peculiarities of changing parameter values α, β.

To determine the optimal from the point of view of satisfaction of interests of both participants of the vertical marketing channel of the scenario of a business game, we analyze and compare the data of the summary table VIII provided that $\alpha = \beta = 0{,}9$.

As can be seen from the data in table VIII, both variants of Stackelberg's business game indicate a shift of power in favor of the manufacturer-leader in a vertical marketing channel. This is evidenced by the magnitude of the manufacturer's profits $\Pr_m$ in excess of the intermediary's earnings $\Pr_r$, as well as the value of the transfer price p_t and the retail price p_r.

The presence of a conflict of interest in the distribution channel, provided that the equilibrium of the manufacturer according to Stackelberg is manifested in the overestimation of the retail price and in obtaining a much greater profit to the manufacturer than the intermediary.

Table- VIII: Summary of strategies and results of two Stackelberg business game scenarios for vertical marketing channel participants

Model's variable	Manufacturer Stackelberg Equilibrium	
	$c_{am} = 0$	$c_{am} > 0$
Manufacturer's profit, $\Pr_m$	1.043.034.953	956.349.223
Mediator's profit, $\Pr_r$	548.965.765	331.429.409
Manufacturer's transfer price, $\Pr_{ch}$	1.592.000.718	1.287.778.632
Channel Profit, p_t	0,4872	0,5906
Reseller retail price p_r	0,7436	0,7953
Manufacturer's costs for joint product advertising, v	0,3643	0,3962
The cost of a reseller for joint product advertising, w	0,3643	0,3962

The presence of a conflict of interest in the distribution channel, provided that the equilibrium of the manufacturer according to Stackelberg is manifested in the overestimation of the retail price and in obtaining a much greater profit to the manufacturer than the intermediary. So, provided that $c_{am} = 0$, the profit of the manufacturer exceeds the profit of the intermediary by 1,9 times, and at - accordingly $c_{am} > 0$ by 2,9 times. This demonstrates the possibility of the manufacturer abusing his leadership position, especially when $c_{am} > 0$. Changing the rate of participation of a manufacturer in the cost of an intermediary for product advertising only affects the increase in their compatible costs w, v, but in no way affects their redistribution. Therefore, the variant of Stackelberg's business game $c_{am} = 0$, which involves forming the equilibrium of the manufacturer at $c_{am} > 0$, cannot be considered practical from the point of view of the possibility of its adaptation to the real conditions of functioning of distribution networks. With regard to the equilibrium of the producer according to Stackelberg, then, being a more attractive scenario of a business game than the previous one, this case of interaction between the manufacturer and the reseller is beneficial only to the manufacturer because it provides him with higher profit than the reseller and also has a much higher transfer price. Despite the possibility of a conflict situation in the distribution channel, the proposed model of equilibrium formation by Stackelberg manufacturer can be used as an information base for a thorough analysis of the possibilities of interaction between the two participants of the vertical marketing channel. The results of the numerical experiment can form the basis for developing recommendations for selecting cost-effective strategies for jointly promoting parameter values α,β from a different range than the proposed study.

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