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PLANNING OF ADVERTISING COSTS AND VENDOR NUMBER AT E-TRADE MARKET

The problem mentioned in the tile is investigated in the framework of Salop model with symmetric product differentiation under assumption that advertising costs represent a consumer utility function parameter, which directly moves the demand curve. The research demonstrates that in case of e-trade market expansion, the income of online vendors increases proportionally to the increase in the number of buyers, while advertising costs increase proportionally to cubic dependence on the number of buyers. It is shown that the number of vendors at the e-market in competitive equilibrium with free entry exceeds the socially optimal number of vendors, since the advertising costs of each vendor under competitive equilibrium turn out to be lower than the optimal level.

Keywords: *Salop model; e-trade; advertising costs; socially optimal number of vendors.*

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ПЛАНУВАННЯ ВИТРАТ НА РЕКЛАМУ І КІЛЬКІСТЬ ПРОДАВЦІВ НА ЕЛЕКТРОННОМУ ТОРГОВЕЛЬНОМУ РИНКУ

У статті використано класичну модель Селопа із симетричною диференціацією товарів у припущенні, що рекламні витрати є параметром функції споживчої корисності, яка безпосередньо зміщує криву попиту. Показано, що при вільному вході на електронний торговельний ринок прибуток Інтернет-продавців збільшується пропорційно до кількості покупців, у той час як витрати на рекламу збільшуються пропорційно до кубічної залежності від числа покупців. Доведено, що кількість продавців на електронному ринку в конкурентній рівновазі з вільним входом перевищує соціально оптимальну кількість продавців, оскільки витрати кожного з продавців на рекламу в конкурентній рівновазі є нижчими за оптимальний рівень.

Ключові слова: *електронна торгівля; модель Селопа; рекламні витрати; соціально оптимальна кількість продавців.*

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ПЛАНИРОВАНИЕ ЗАТРАТ НА РЕКЛАМУ И КОЛИЧЕСТВО ПРОДАВЦОВ НА ЭЛЕКТРОННОМ ТОРГОВОМ РЫНКЕ

В статье использована классическая модель Селопа с симметричной дифференциацией товаров в предположении, что рекламные затраты являются параметром функции потребительской полезности, которая непосредственно сдвигает кривую спроса. Показано, что при свободном входе на электронный торговый рынок прибыль Интернет-продавцов увеличивается пропорционально количеству покупателей, в то время как затраты на рекламу увеличиваются пропорционально кубической зависимости от числа покупателей. Доказано, что количество продавцов на электронном рынке в конкурентном равновесии со свободным входом превышает социально оптимальное количество продавцов, поскольку затраты каждого из продавцов на рекламу в конкурентном равновесии оказываются ниже оптимального уровня.

Ключевые слова: *электронная торговля; модель Селопа; рекламные затраты; социально оптимальное количество продавцов.*

Problem setting. E-commerce, as compared to traditional business, has substantial advantages. In particular, the use of new electronic communication channels sig-

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nificantly reduces costs related to organization and support business infrastructure, and the possibilities of e-commerce allow re-designing business strategy at any moment. Another important phenomenon of electronic markets that calls for explication is high concentration and high ratio of advertising costs to revenue, which is characteristic of the largest online stores (Turban et al., 2015). Such high marketing costs point to the fact that advertising in electronic markets plays a much more important role as compared to conventional markets.

Review of recent publications. The role of advertising costs in economic activity was studied by F.M. Bass et al. (2005), G.M. Erickson (2009), D. Favaretto and B. Viscolani (2000), M. Meurer and O. Dale (1984), L.M. Nichols (1985), S.P. Sethi (1983) and others. However, at present, there is no generally accepted theory that would adequately describe advertising costs role at electronic trade markets.

The purpose of this paper is to study the problem of central planning, in which the number of vendors at a e-market and the amount of advertising costs incurred by each online vendor are selected simultaneously. For this research, Salop model (1979) with symmetric product differentiation has been chosen as a basis. Salop model assumes that product and service vendors are not identical for buyers, since they are located at different distances from them. As regards e-trade, one can speak of a conditional remoteness of buyers in the space of product and service specifications, since consumer virtually does not move in space when shopping, for him/her this distance correlates with monetary costs pertaining to product delivery. Therefore, we believe that depending on their priorities, buyers give preference to one or another online vendor, i.e., the conditional distance to the most preferred vendor is smaller than that to others.

As distinct from the models presented in (Butters, 1977; Grossman and Shapiro, 1984; Shapiro, 1980), we argue that advertising is not informative. Information at a market is generally accessible, thus advertising serves solely for the change of consumer preferences. In the model, it is presumed that the quantity of advertisement is included as the utility function shift parameter, as presented in (Dixit et al., 1982).

Results and discussion. In the present study, a modification of Salop circular city model has been undertaken taking into account the possibility of Web-based vendors impacting consumers' preferences by means of non-informative advertising. In the modified model, we believe that advertising costs are a parameter of consumer utility function, which directly moves the demand curve, increasing product utility for buyers and their readiness to pay. Also in the modified Salop model, the linear function of transport costs was replaced with the quadratic function of transaction costs (Pan et al., 2002).

Let us assume that at e-trade market there exist l online vendors and n buyers evenly distributed throughout the market with linear dimensions (0,1). Any consumer at such a market is positioned at the distance of $x \in (0,1/l)$ from the closest vendor. Purchasing products online buyers pay the overall product price (Dixit and Norman, 1982), which includes, in addition to product price, also transport costs. Consumers' transaction costs in e-trade are functionally contingent upon the number of views of Internet shops with the aim of buying a product, the average load of each of product marketing channels, the number of buyer addresses along the product delivery route, the total distance of delivery routes, product weight and tariffing coefficient. In general terms, buyers' transaction costs in e-trade may be presented by means of a quadratic function (Pan et al., 2002):

$$TP = tx^2, \tag{1}$$

where t is a transaction unit cost; x is the distance from a buyer to an online vendor.

When taking into account advertising costs, the overall price Pr paid by the buyer at the purchase of a product can be presented as a function of product price P, transaction TP and advertising costs R:

$$Pr = f(P, TP, R). \tag{2}$$

Marginal costs of selling a product unit to the buyer are constant for all vendors and equal to C. In addition to marginal costs, online vendors incur additional fixed costs C_0 in connection to entering the e-trade market. The market provides for each buyer the fulfillment of their demand (the quantity of products is large enough to secure a purchase of at least one product unit for each buyer), due to which they receive their consumer utility from consuming the purchased product. In this model, we assume that each of l online vendors may promote both their online shop and their products, which by all means brings about the increase of the overall price of the product. Vendor's advertising campaign increases the demand for goods, and, consequently, leads to income increase. The mechanism of advertisement impact upon the preferences of consumers is designed in such a manner that in order to secure the highest consumer utility Q of a product, jth vendor must have advertising costs R_j. In this case, the highest consumer utility constitutes the maximum price Pr_j, which a buyer is ready to pay for a product unit of the jth vendor, with respective advertising costs R_j (Butters, 1977; Dixit and Norman, 1982):

$$Q_j = Pr_j(R) = qR_j^{\,g}, \tag{3}$$

where q is a coefficient which characterizes consumer awareness (we deem it to be a constant value, since in e-trade environment advertising is mainly not informative, but manipulative); g is a coefficient within the range from 0 to 1, connected with the existence of a certain margin of advertising investment saturation explained by the decrease of coverage increment and the exhaustion of buyer readiness to buy advertised products.

In e-trade, the influence of advertising costs on product price indicators may be presented in the form of the following difference:

$$Infl(R) = Pr_j(R) - P - TP. \tag{4}$$

Taking into account formulas (1) and (3), it happens so that in the state of equilibrium in case of symmetric product differentiation, a consumer, located at the distance of x from vendor j or at the distance $(1/l\text{-}x)$ from its neighbor, does not receive any advantage from purchasing a product unit from online vendors being closest to him in the space of e-trade market, if:

$$qR_j^{\,g} - P_j - tx^2 = qR^g - P - t\left(\frac{1}{l} - x\right)^2. \tag{5}$$

Having solved equation (5) in respect of x, we arrive at the fact that under prices equilibrium and n consumers, jth vendor has the following demand for its products:

$$Dem_j = nx = nl\left(\frac{qR_j^{\,g} - qR^g - P_j + P + \frac{t}{l^2}}{2t} \right). \qquad (6)$$

To increase profit, a vendor may variate prices P_j and advertising costs R_j. Then the maximal profit of the jth vendor may be determined by the following function:

$$\pi_j(P,R) = maa\left\{ nl(P_j - C)\left(\frac{qR_j^{\,g} - qR^g - P_j + P + \frac{t}{l^2}}{2t} \right) - R_j - C_0 \right\}. \qquad (7)$$

We deem it that all Web-based vendors simultaneously make decisions with regard to prices and advertising costs. We also deem that all vendors incur unchanged marginal costs C and identical additional fixed costs C_0 when entering the e-market. The condition of maximum profit is created by way of differentiating equation (7) and equating the derivative to zero. According to Nash equilibrium (Nash, 1951), in a consecutive one-period decision-making game, the first-order conditions of vendor's optimization problem will look as follows:

$$\left.\begin{aligned} \frac{\partial \pi_j}{\partial P_j} &= qR_j^{\,g} - qR^g - 2P_j + P + \frac{t}{l^2} + C = 0 \\ \frac{\partial \pi_j}{\partial R_j} &= \frac{nl(P_j - C)}{2t} gqR_j^{\,g-1} - 1 = 0 \end{aligned}\right\}. \qquad (8)$$

In the classical oligopoly theory, for a one-period model (Wang, 1988), in the condition of symmetric Nash equilibrium, vendors set same prices P_j and advertising costs R_j likewise. In that case, in a situation of symmetric product differentiation, the following values of price P^E and advertising costs R^E can be determined as:

$$P^E = \frac{t}{l^2} + C; \qquad (9)$$

$$R^E = \left(\frac{2l}{gqn} \right)^{\frac{1}{g-1}}. \qquad (10)$$

We assume that vendors may freely enter the e-trade market. At the same time, each new vendor incurs respective costs C_0 in connection with entering the market (Eaton and Lipsey, 1978). If the number of vendors at the e-trade market is endogenic, their number is determined basing on the zero profit condition:

$$\pi_j(P,R) = \frac{n}{l}(P^E - C) - \frac{R^E}{l} - C_0 = 0. \qquad (11)$$

When plugging the saturation coefficient value of $g = 2/3$ into equation (10), for advertising costs in equilibrium conditions, we get:

$$R^E = \left(\frac{qn}{3l} \right)^3 = \frac{q^3 n^3}{27 l^3}. \qquad (12)$$

Taking into account (9) and (12), the number of vendors in equilibrium is determined by the following equation:

$$\pi(P,R)=\frac{n}{l}\left(P^E-C\right)-R^E-C_0=\frac{nt}{l^3}-\frac{q^3n^3}{27l^3}-C_0=0. \tag{13}$$

Hence, we receive a direct expression of the number of vendors in case of free entry to the market under competition:

$$l^C=\frac{1}{3}\sqrt[3]{\frac{27nt-q^3n^3}{C_0}}. \tag{14}$$

Let us consider the problem of central planning, in which selected simultaneously is the number of vendors at the e-market and the size of advertising costs incurred by each vendor. From the viewpoint of social optimum, the number of vendors must be such that the overall utility of all consumers Q, excluding cumulative fixed costs, cumulative transport costs, and cumulative advertising costs, is maximal. Taking into account the fact that in e-trade transaction costs have quadratic dependence on the distance (Pan et al., 2002), the problem of choosing a socially optimal number of vendors at the market looks as follows:

$$Q=max_{l,R}\left[nqR^g-nt\left(2l\int_0^{\frac{1}{2l}}x^2dx\right)-l\left(R+C_0\right)\right]. \tag{15}$$

Upon integration

$$Q=max_{l,R}\left[nqR^g-\frac{nt}{12l^2}-l\left(R+C_0\right)\right], \tag{16}$$

from first-order conditions, we will receive

$$\left.\begin{aligned}\frac{\partial Q}{\partial R}&=gnqR^{g-1}-l=0\\ \frac{\partial Q}{\partial l}&=\frac{nt}{6l^3}-R-C_0=0\end{aligned}\right\}, \tag{17}$$

with the value $g = 2/3$ the following stems from equations (17):

$$R^*=\frac{8q^3n^3}{27l^3}; \tag{18}$$

$$l^*=\frac{1}{3}\sqrt[3]{\frac{9nt-16q^3n^3}{2C_0}}, \tag{19}$$

where R^* and l^* are the solution of the central planning problem.

Let us consider the problem of choosing the maximum number of vendors at the e-market, positioned under competitive equilibrium, but the entry to the market is closed. In this case the volume of advertising costs shall be determined by the first-order condition for competitive equilibrium (12). With respective plugging of R^E, the planning problem looks as follows:

$$Q=max_l\left[\frac{q^3n^3}{9l^2}-nt\left(2l\int_0^{\frac{1}{2l}}x^2dx\right)-\frac{q^3n^3}{27l^2}-lC_0\right]. \tag{20}$$

After integration, we will receive the following:

$$Q = max_l\left[\frac{2q^3n^3}{27l^2} - \frac{nt}{12l^2} - lC_0\right]; \tag{21}$$

$$\frac{\partial Q}{\partial l} = \frac{nt}{6l^3} - \frac{4q^3n^3}{27l^3} - C_0 = 0; \tag{22}$$

$$l^{**} = \frac{1}{3}\sqrt[3]{\frac{9nt - 8q^3n^3}{2C_0}}. \tag{23}$$

Thus, the number of vendors at the e-market under competitive equilibrium with free entry exceeds the socially optimal number of vendors $l^C > l^*$. In its turn, the optimal number of vendors under competitive equilibrium with closed market entry exceeds the optimal number of vendors under competitive equilibrium with free entry $l^{**} > l^*$. In this case, advertising costs of each vendor turn out to be below the optimal level of $R^E < R^*$. It is noteworthy that cumulative advertising costs under competitive equilibrium, even despite the larger number of vendors compared to social optimum, are also lower than in the solution of the central planning problem.

Conclusion. The analysis of findings points to the fact that in case of free entry to e-trade market, the income of vendors grows proportionally to the number of consumers, while advertising costs increase proportionally to n^3. As a result, as e-market expands, advertising costs of each vendor grow at a rate that surpasses the received profit.

Under equilibrium with free entry, after the threshold values $n_{th} > \sqrt{9t/q^3}$ are are reached, market expansion leads to the decrease in the number of vendors at the e-market, since the surpassing growth of advertising costs reduces vendors' profits. The number of vendors at the e-market under competitive equilibrium with free entry exceeds the socially optimal number of vendors, since advertising costs of each vendor turn out to be below the optimal level.

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