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K. Zadko
ORCID ID: 0000-0003-2097-3582

O. Stets
PhD in Physico-mathematical sciences, Associate Professor
ORCID ID: 0000-0001-5514-3533

National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

SIMULATION OF THE ACTIVITIES OF SUBJECTS OF E-BUSINESS ON THE BASIS OF A COMPATIBLE PROBABILISTIC MODEL

МОДЕЛЮВАННЯ ДІЯЛЬНОСТІ СУБ'ЄКТІВ ЕЛЕКТРОННОГО БІЗНЕСУ НА ОСНОВІ СКЛАДНОЇ ЙМОВІРНІСНОЇ МОДЕЛІ

The article deals with the situation of e-commerce and e-business in the conditions of modern economy of Ukraine. The relevance of this study is especially high today, because the success of electronic business depends primarily on the introduction of innovative projects based on the economic and mathematical modeling of the subjects of electronic business. The use of the probabilistic model for modeling the activity of the subject of electronic business is proposed to simulate the model of S. Patel and A. Schlizher, which is based on a simple probabilistic model and takes into account some psychological effects of consumer behavior when choosing goods in the market. In this model, the following effects are considered: the effect of minimizing damage, the effect of assessing the importance of qualities and properties, the effect of minimizing the distance to the average commodity. The research is based on the study of the work of scientists-economists, on the synthesis and complex analysis of domestic and foreign studies of consumer behavior in the context of e-commerce. Among the methods used in the study can be distinguished such as observation, analysis and synthesis, the method of modeling. In determining the probability of selecting a platform in this model, the utility function is used. Based on the probability transition matrix, a consumer choice model was developed between two e-commerce platforms. The use of this model for the companies' choice of platforms for the implementation of their activities, as well as for the evaluation of the activity of the Internet platforms in general, is proposed. The results of modeling are the forecast distribution of market share between competitors. During the research the following tasks were fulfilled: the state of the e-commerce market in Ukraine was studied; the behavior of the subject of e-business has been explored; statistical information has been collected and processed in relation to the research object; the model of behavior of Internet consumers with the help of the chosen model was constructed.

Keywords: e-business, e-commerce, consumer, online trading platform.

У статті розглянуто становище електронної комерції та електронного бізнесу в умовах сучасної економіки України. Актуальність даного дослідження сьогодні особливо висока, адже успіх електронного бізнесу залежить насамперед від запровадження інноваційних проектів заснованих на економіко-математичному моделюванні діяльності суб'єктів електронного бізнесу.Запропоновано використання ймовірнісної моделі для моделювання діяльності суб'єкта електронного бізнесу математичну модель С. Пателя та А. Шліжпера, яка будується на основі простої ймовірнісної моделі та враховує деякі психологічні ефекти поведінки споживача при виборі товарів на ринку. В даній моделі розглянуто наступні ефекти: ефект мінімізації шкодування, ефект оцінки важливості якостей та властивостей, ефект мінімізації відстані до середнього товару. Дослідження базуються на вивченні робіт вчених-економістів, на узагальненні та

комплексному аналізі вітчизняних та закордонних досліджень поведінки споживачів у розрізі e-commerce. Серед методів, застосованих при дослідженні можна виокремити такі як спостереження, аналізу та синтезу, метод моделювання. При визначенні ймовірності вибору платформи у даній моделі використовується функція корисності. На основі матриці ймовірнісних переходів побудовано модель вибору споживачів між двома платформами електронної комерції. Запропоновано використання даної моделі для вибору компаніями платформ щодо здійснення своєї діяльності, а також для оцінки діяльності власне інтернет – платформ в цілому. Результатами моделювання є прогноз розподілення долі ринку між конкурентами.В ході дослідження виконано наступні завдання: вивчено стан ринку електронної комерції в Україні; досліджено поведінку суб'єкта електронного бізнесу;зібрано та опрацьовано статистичну інформацію, стосовно об'єкта дослідження; побудовано модель поведінки інтернет- споживачів за допомогою обраної моделі.

Ключові слова: електронний бізнес, електронна комерція, споживач, платформа онлайн-торгівлі.

Introduction. To date, the global nature of the development of economic relations, as well as the rapid development of information and communication technologies, have created a new form of relationship: e-commerce and e-business. Now we can observe the rapid development and conditions for the further growth of the share of e-commerce in the Ukrainian market, which positively affects the economic situation and opens new business opportunities. Among the benefits created, one can distinguish the following: rapid reaction to demand; new opportunities for doing business; sales personalization; global presence and expansion of geography; low operating costs; rapid development of a competitive environment. The relevance of this study is especially high today, because the success of electronic business depends primarily on the introduction of innovative projects based on the economic and mathematical modeling of the subjects of e-business.

The development of e-commerce is very fast. For a fairly short period of its existence, it has received extensive research in the domestic economy in foreign literature. Among the authors who investigated this problem are the following: Melnyk OV, Bublikhenko O.V., AmmosovYu.M.,Lyapunov SI, Uspensky IN, Lowe P., Eimora D., Carver D. Clark R., Matou A., Schneider B., Eimor D. The questions of mathematical modeling of consumer behavior are dealt with both domestic and foreign researchers: B. Lipstein highlighted the special influence of advertising on the consumer's choice, his loyalty; S.T Charles, in the consumer behavior model, considered incentives that affect consumers in the decision-making process for purchasing a product. He highlighted marketing communications as one of the most important factors affecting consumers. This model is based on four components: motivation, incentives, attention, acquisition .; V.L. Beresnev, V.I. Suslov constructed a model that takes into account the three stages of decision-making by the consumer; A.M. Semiglazov, V.A. Semiglazov, K.I. Ivanov worked on a mathematical model that allows us to construct, with the utmost precision, the forecast of the economic efficiency of the impact on the consumer in the decision-making process concerning the purchase of goods with the help of advertising; I.B. Kashirina, V.G. The consultant in the regression model of demand has taken into account the influence of social and demographic

factors on the prediction of consumer behavior ; S. Patel, A. Schlizher in the probabilistic model took into account the psychological characteristics of consumer behavior when buying a product. In the composition of the model, they included effects that describe these particulars.

Statement of the problem. The purpose of this study is economic and mathematical modeling of the subject of e-business, studying the behavior of Internet consumers in a market economy.

Methodology. The research is based on the study of the work of scientists-economists, on the synthesis and complex analysis of domestic and foreign studies of consumer behavior in the context of e-commerce. Among the methods used in the study can be distinguished such as observation, analysis and synthesis, the method of modeling.

Resultsof research. In Ukraine, there is a rapid and rapid development of the e-commerce market, and an increase in the number of Internet transactions due to increased re-purchases and the emergence of new Internet consumers. The process of making purchases in the Internet environment is significantly different from the process of purchasing a product in a traditional store because of the virtual presentation of the product and the conditions for its delivery. In the behavior of Internet consumers, which differs from traditional behavior, there are various effects, in particular, the effect of the rupture of the value of virtual money, which has been studied with varying degrees of completeness. In order to most effectively sell products on the Internet, a great deal of Internet consumer research is being conducted and models of their behavior are being developed [5]. The models examine individual cases of consumer behavior on the Internet for different types of products, commodity markets and options for organizing sales processes [3]. Since the environment of the decision-making process of the consumer about the purchase is different and in the process of purchasing the Internet there is various effects, it is necessary to conduct an analysis of consumer behavior models. The consumer behavior model is a conditional image of consumer behavior, created to study its behavior and develop the most appropriate marketing activities of enterprises using such marketing tools as product offerings, pricing, advertising, promotion, branding, and more [7].

The main idea of this study is to model the behavior of consumers who are subjects of e-commerce. Such models should take into account the various psychological and social factors that adequately describe how consumers influence what is being sold and who buys it. The results of the simulation should be a forecast distribution of market share between competitors.

The mathematical model by S. Patel and A. Schlizher is based on a simple probabilistic model and takes into account some psychological effects of consumer behavior when choosing goods on the market. In this model, the following effects are considered:

- the effect of minimizing harm;
- the effect of assessment of the importance of qualities and properties;
- the effect of minimizing the distance to the average commodity.

This article is presented in the form of a complex probabilistic model, which consists of three models, which take into account the influence of individual effects on the basis of a simple probabilistic model. This article examines the behavior of online consumers, which takes into account the behavior of consumers in the market, where there is a choice between two online trading platforms, which are platforms for the opening of online stores, and the presentation of their products in a single directory. The probability of choosing a platform depends on its previous choice, in mathematical terms it looks like this:

$$\begin{cases} p_{12(m+1)} = \alpha_{11}^{*} p_{12m} + \alpha_{21}^{*} p_{21m} \\ p_{21(m+1)} = \alpha_{12}^{*} p_{12m} + \alpha_{22}^{*} p_{2m} \end{cases} \quad (1)$$

where p_{12} - the probability of purchasing goods on the first platform;

p_{21} - probability of purchasing goods by the consumer on the second platform;

m - time interval;

α_{11}^{*} - the probability of giving preference to the first platform, subject to the prior selection of the first;

α_{12}^{*} - the probability of favoring the second platform, with the prior selection of the first one;

α_{21}^{*} - the probability of favoring the first platform, subject to the prior selection of the first second;

α_{22}^{*} - the probability of favoring the second platform, provided the previous choice of the second one.

α_{ij} - forms a matrix of transitions ($\alpha_{11}^{*} + \alpha_{21}^{*} = 1 = \alpha_{12}^{*} + \alpha_{22}^{*}$) and the process is presented as a Markov chain.

Moving to a continuous process (allowing the time step to be reduced to 0 at $\alpha_{11}^{*} \to 1, \alpha_{22}^{*} \to 1$ probabilities $p_1(t)$ and $p_2(t) = 1 - p_1(t)$ the choice of each platform is now calculated by the system of differential equations:

$$\begin{cases} \frac{dp_1}{dt} = \alpha_{11}^{*} p_1 + \alpha_{12}^{*} p_2 \\ \frac{dp_2}{dt} = \alpha_{21}^{*} p_1 + \alpha_{22}^{*} p_2 \end{cases} \quad (2)$$

If you put N - the number of people who behave in a typical, but on their own, expected market share develops according to the system (28).

Assuming that the values are quite large and that consumers can be considered as varying the determinant X can be considered as part of the population. Then the model will look like:

$$\begin{cases} \frac{dX_1}{dt} = \alpha_{11}^{*} X_1 + \alpha_{12}^{*} X_2 \\ \frac{dX_2}{dt} = \alpha_{21}^{*} X_1 + \alpha_{22}^{*} X_2 \end{cases} \quad (3)$$

These groups must satisfy the condition $X_1 + X_2 = 1$. The secondary diagonal elements α_{ij} – determine the speed with which consumers change the choice of platform i from the platform j, when i≠j.

We can assume that each interval of time pV once recycled, consumers visit the platform by buying or not buying a product. For some m time interval pp_1V is bought on the first online platform and pp_2V on the second. Then the volume of purchased goods per unit time:

$$\begin{cases} V_1^{1b} = pp_1V \\ V_2^{1b} = pp_2V \end{cases} \quad (4)$$

For the commodity market, the probability of purchasing goods based on the initial data of the model will look like:

$$\begin{cases} p_{1(m+1)} = \alpha_{11}^* X_{1m} + \alpha_{12}^* X_{2m} \\ p_{2(m+1)} = \alpha_{21}^* X_{1m} + \alpha_{22}^* X_{2m} \end{cases} \quad (5)$$

(5) shows the fate of the goods in the market at the time m.

The number of times a buyer leaves the platform without making a purchase at random is:

$$\begin{cases} V_1^{1u} = pX_1V \\ V_2^{1u} = pX_2V \end{cases} \quad (6)$$

Thus, the volume of purchases of goods on online platforms at the moment (m+1):

$$\begin{cases} V_{1(m+1)} = X_1V_m + pp_1V_m - pX_1V_m \\ V_{2(m+1)} = X_2V_m + pp_2V_m - pX_2V_m \end{cases} \quad (7)$$

Then the new market shares at the moment (m + 1):

$$V_{1(m+1)} + V_{2(m+1)} = V_m \quad (8)$$

$$X_1V_m + pp_1V_m - pX_1V_m + X_2V_m + pp_2V_m - pX_2V_m = V_m \quad (9)$$

Accordingly, the fate of online platforms on the market at the time (m + 1):

$$\begin{cases} X_{1(m+1)} = X_1 + pp_1 - pX_1 \\ X_{2(m+1)} = X_2 + pp_2 - pX_2 \end{cases} \quad (10)$$

Psychological effects.

1. Minimize anticipated regret. This property was adopted in order to reduce to simple comparable comparisons all that concerns quality (k) than a platform I better than platform j. Matrix of probabilistic transitions A^* (2) is calculated on the basis of assessments of the qualities of online platforms. Both platforms are compared for a given number of properties. Each of them is evaluated on a continuous scale in points.

Q_{k1} - evaluation of the k-th property of the first platform, where $k = 1\text{K}\ n_q$

Q_{k2} - evaluation of the k-th property of the second platform, where $k = 1\text{K}\ n_q$

n_q - number of comparable properties, where $n_q = 1\text{K}\ q$

On the basis of integral properties, we can conclude that consumers tend to change their place of purchase. Calculation of the coefficient a_{12}^{mar} is carried out on the basis of determining the number of properties for which the second platform is better than the first:

$$a_{12}^{mar} = \frac{N_{21}^{+}}{n_q} \tag{11}$$

where N_{21}^{+} - the number of qualities for which a friend is better than the first one.

Determining the number of properties for which the second platform is better than the first, occurs through the Heviside function by the following formula:

$$N_{21}^{+} = \sum_{k=1}^{n_q} H(Q_{k2} - Q_{k1}) \tag{12}$$

Taking into account (38) the probability of visiting the first online trading platform will be:

$$a_{12}^{mar} = \frac{\sum_{k=1}^{n_q} H(Q_{k2} - Q_{k1})}{n_q} \tag{13}$$

Accordingly, the probability of visiting the first platform will depend on the number of qualities that it is better than a second.

2) The Effect of Assessing the Importance of the Properties of Online Trading Platforms

This effect is to assess the utility of the selected platform. The utility is considered by the consumer as the ability to meet the necessary needs, and also reflects the consumer's relation to this platform.

In determining the probability of selecting a platform in this model, the utility function is used. The utility function determines the preferences of the consumer, where the utility of the utility function is the rational behavior of the consumer, which is expressed in the choice of many alternatives of those trading platforms that have the highest level of usefulness.

The utility function for each of the product alternatives is determined using the coefficient β_k and a quantitative assessment of the quality of the properties of the platform Q_k. The coefficient may on the market, in particular the position of the brand in the quality space and how consumers perceive which of the qualities the best is. The value of the coefficient β_k depends on how consumers evaluate every feature of the platform at the level of importance for themselves when choosing and buying goods.

$$\sum_{k=1}^{n_q} \beta_{\mathrm{k}} = 1, \tag{14}$$

where β_{k} - is coefficient of importance of properties, which has positive values.

For a plurality of products with a set of properties that determine the quality of a product, the utility function will look like:

$$U^*(Q) = \sum_{k=1}^{n} \beta_k Q_k \tag{15}$$

$$\beta = 1/\sqrt{\sum_k \beta_k^2} \tag{16}$$

$$U(Q) = (\beta + \beta^*)Q + \sum_{k=2}^{n_q} \beta_k Q_k \tag{17}$$

Utility function $U(Q)$ includes all the values of the evaluation of the quality of the services of the platform, if $U(Q_1) > U(Q_2)$, then the first platform is better than the other. With this comparison, consumers are more loyal to the first site, respectively, the probability of visiting the first will be higher $\alpha_{21}^* > \alpha_{12}^*$.

Thus, the probability of purchasing the first product will be:

$$a_{21}^{ac} = \frac{U(Q_1)}{U(Q_1) + U(Q_2)} \tag{18}$$

Similarly, the probability of choosing a second platform, if it is better than the first:

$$a_{12}^{ac} = \frac{U(Q_2)}{U(Q_1) + U(Q_2)} \tag{19}$$

Formulas (44) - (45) are used to calculate transition probabilities choice of trading platform effect considering the importance assess properties.

3) The effect of minimizing the distance to the "average".

The effect of minimizing the distance to the middle ground means that consumers are inclined to change the solution in favor of the platform, which is close to the qualitative estimates to the "average". The middle platform as the center of mass in the category of quality can be calculated by the formula:

$$\overline{Q} = \frac{1}{n_p} \sum_{k=1}^{n_q} Q_k \ , \tag{20}$$

where n_p - is number of platforms.

The average quality score is calculated by the number of platforms being considered. The average can be weighted according to the calculations from the platform to the second platform and center of mass. The calculation of the distance between the platforms can be calculated by the formula:

$$d_{12} = d(Q_1, Q_2) = \sum_{k=1}^{n_q} |Q_{k1} - Q_{k2}|, \tag{21}$$

where d – is distance between platforms.

When comparing two platforms, the distance from two platforms to the center of mass is calculated: $d_1 = d(Q_1, \overline{Q})$ and $d_2 = d(Q_2, \overline{Q})$. The transition probabilities of the site visit take positive values at the interval [0,1], so in this case it is necessary to the expression $\frac{d_1 - d_2}{d_1 + d_2}$ add 1 and divide by 2.

$$\alpha_{12}^{oa} = (1 + \frac{d_1 - d_2}{d_1 + d_2}) / 2 \quad (22)$$

$$\alpha_{21}^{oa} = (1 + \frac{d_2 - d_1}{d_1 + d_2}) / 2 \quad (23)$$

The formulas (48) - (49) calculate the transition factor to the second platform.

When choosing a platform, the consumer is under the influence of several effects in one degree or another. Each effect has a different impact.

Let's accept χ is the coefficient of importance of each effect that independently influences the behavior of the consumer when choosing a platform, provided:

$$\sum \chi_i = 1 \quad (24)$$

The complex probabilistic model of consumer behavior in choosing one of the two items described conversion matrix A *.

It can be set due to the probabilities of transitions α_{12}^{*} and α_{21}^{*}.

These probabilities in a simple model can be calculated on the basis of market analysis. For a complex model, taking into account the psychological effects of consumer behavior, the probability of purchasing a product can be obtained in a more complex formula:

$$\alpha_{12}^{*} = \chi_0 \alpha_{12}^{0} + \chi_1 \alpha_{12}^{mar} + \chi_2 \alpha_{12}^{ac} + \chi_3 \alpha_{12}^{oa} , \quad (25)$$

where α_{12}^{0} - the probability of visiting the second platform, taking into account the effects not allocated in this model, is given;

α_{12}^{mar} - probability of visiting the second platform, taking into account the effect of minimizing harm;

α_{12}^{oc} - the probability of visiting the second platform, taking into account the effect of assessing the importance of the properties;

α_{12}^{oa} - the probability of visiting the second platform, taking into account the effect of minimizing the distance to the average product;

χ_0 - the influence of the effects not isolated in this model;

χ_1 - the effect of the effect of minimizing harm;

χ_2 - the influence of the effect of the assessment of the importance of properties;

χ_3 - the effect of the effect of minimizing the distance to the average.

$$\alpha_{12}^{*} = \chi_0 \alpha_{12}^{0} + \chi_1 \frac{\sum_{k=1}^{n_q} H(Q_{k2} - Q_{k1})}{n_q} + \chi_2 \frac{U(Q_2)}{U(Q_1) + U(Q_2)} + \chi_3 \left(1 + \frac{d_1 - d_2}{d_1 + d_2}\right) / 2 \quad (26)$$

$$\alpha_{21}^{*} = \chi_0 \alpha_{21}^{0} + \chi_1 \frac{\sum_{k=1}^{n_q} H(Q_{k1} - Q_{k2})}{n_q} + \chi_2 \frac{U(Q_1)}{U(Q_1) + U(Q_2)} + \chi_3 \left(1 + \frac{d_2 - d_1}{d_1 + d_2}\right) / 2 \qquad (27)$$

We set initial market shares occupying the company: X1 = 0,6, X2 = 0,4. When solving the system we get the dynamics of distribution of buyers choice in the next 6 months.

Consequently, we will have such market shares in the next 6 months:

Table 1- Data without taking into account psychological effects

Number of month	p1	p2
1	0,8	0,2
2	0,731959	0,268041
3	0,6781	0,3219
4	0,635997	0,364003
5	0,603404	0,396596
6	0,578364	0,421636
7	0,559237	0,440763

By formulas (28-29) we calculate the finite values of elements of the matrix of transition probabilities taking into account psychological effects on the basis of expert estimates.

$$\alpha_{12} = 0{,}388048, \qquad \alpha_{21} = 0{,}47351$$

Then we will have a market share taking into account psychological effects in the next 6 months:

Table 2- Data taking into account psychological effects

Number of month	p1	p2
1	0,8	0,2
2	0,666498	0,333502
3	0,593445	0,406555
4	0,552769	0,447231
5	0,529903	0,470097
6	0,516978	0,483022
7	0,50965	0,49035

Conclusions. During the research the following tasks were fulfilled: the state of the e-commerce market in Ukraine was studied; the behavior of the subject of e-business has been explored; statistical information has been collected and processed in relation to the research object; the model of behavior of Internet consumers with the help of the chosen model was constructed. This model could improve and simplify the implementation of the choice of online trading platform for enterprises, as well as help to identify the problem sides of the Internet platforms.

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