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Customer Transaction Costs Simulation in E-Commerce

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ABSTRACT
The present study reports the results of simulating the customer transaction costs in e-commerce. In this investigation, we have focused our attention to influence of introduction of the collective product delivery routes and the level of consumer conversion rate on the customer transaction costs in e-commerce. The simulation of customer transaction costs in e-commerce show that they can be significantly reduced by optimizing the delivery routes and increasing conversion rates. A reduction of the customer transaction costs in comparison with individual delivery costs is connected with taking into account in calculation introduction of collective delivery routes. It was found the that reduction of customer transaction costs involves an optimizing the collective routes of goods delivery. The reason for this can be attributed to the fact that the increasing the number of delivery addresses per route can result in a lower delivery costs for per buyer. The maximal effect is observed for central city zone, where it is possible to carry out an effective territorial combination of the addresses of buyers in the delivery route.
Keywords: *e-commerce, transaction costs simulation, customers, collective goods delivery, conversion rate*

1. INTRODUCTION

In recent years [1], electronic trading has grown rapidly, spreading comprehensively and offering an increasingly diverse assortment of goods and services, the e-commerce becomes an instrument for the integration of individuals, enterprises, industries, state institutions and states into a united community, within which the interaction of partners is effectively and unhindered by means of information and telecommunication technologies. E-commerce, as compared to traditional business, has substantial advantages. In particular, the use of new electronic communication channels sig nificantly reduces costs related to organization and support business infrastructure, and the possibilities of e-commerce allow re-designing business strategy at any moment [2, 3].
It should be noted that all trading opportunities of the market through the use of electronic trading technologies with the advent of advanced information and communication tools have become more accessible to small and mediumsized businesses. Small businesses gain access to new consumer markets through the development of B2C e-commerce. Electronic trading of B2B type offers them the wide opportunities for conducting business with large organizations on the basis of the use of electronic delivery technologies, or by way of general release to the entire electronic trading market. All this allows small companies with limited resources to have access to the global market with fully affordable entry costs.
At the same time, effective management of e-commerce development, as well as the processes of the economy informatization as a whole, is impossible without a full and comprehensive economic and mathematical research of the whole complex of problems, including, on the one hand, the activities of enterprises in the field of electronic commerce, and, on the other, the use of information technology in enterprises and organizations of all branches of economy [1, 4-7].
The problem of economic and mathematical modeling of e-commerce processes [8-10] is currently one of the most urgent due to the dynamic growth of this economic activity area, both in terms of trading operations and territorial coverage of potential participants in e-commerce. In connection with these circumstances, arises the task of e-commerce processes analysis and economic and mathematical tools development, which can be used to study the complex patterns of interaction in e-commerce and be the basis for the development of effective management mechanisms.
A major purpose of this study is to customer transaction costs simulation at the electronic trade market in assuming symmetric product differentiation.

2. MODEL

In this study for customer transaction costs simulation in e-commerce we used the model that presented in [11]. Authors [11], when constructing a model of customer transaction costs at the e-trade market proceed from the homogeneity of consumer preferences, or in other words common to all rules and norms of consumer priorities

formation. Consumers have the same value of the goods they buy. But at the same time, when purchasing identical goods, buyers bear different transaction costs, which are determined by the distance between the store location and the buyer [12, 13].
The authors [11] use the classic model of linear trading market that first proposed by H. Hotelling [14] and according to which it is believed that the sellers of goods and services are not identical for buyers, since they are at different distances from them. It is believed that, depending on their preferences, buyers prefer one or another Internet store, that is, the conditional distance to the most attractive seller is less than that to others. In this linear trading market, stores with location *d* and symmetric product differentiation are considered [11].
For electronic trade market, Internet stores that sell the identical products through different sales channels of goods were considered. In electronic commerce can speak about the distance between the buyer and the shop only in a visional sense, because the consumer, buying goods, almost does not move in the space, for him, this distance correlates with certain costs, which involve monetary expenditures in two main distribution channels in electronic commerce: shipping address and shipping to the nearest-to-consumer points of distribution of goods.
In practice, the purchase of goods in an online store is accompanied by the purchase of the whole set of services associated with the delivery of goods. In addition, online store may differ in payment terms (for example: cash payment, bank transfer, credit card payment), warranty terms for goods, etc. Even the ease of applying the user interface of the e-store user can affect the buyers' preferences [15].
It is believe that in the e-trade market, the quantity of goods is large enough to guarantee the purchase of at least one unit of goods for each of *n* buyers. To determine the customer costs (CC) that he pays, the function that depends on the distance between the buyer and the store is used [15, 16]:

$$CC_{ij} = f\left(x_i; L_j\right) \quad (1)$$

where x_i–is the *i*-th buyer buyer's location (it is assumed that all buyers are evenly distributed in the linear trading market); L_j *i*s the location of the *j*-th store [11].
Based on the studies results that presented in [17-19], the authors [11] note that when using this function (1) the following circumstances must also be taken into account: firstly, consumers of electronic commerce in general can buy goods without visiting the store using the appropriate means of delivery of goods; secondly, in electronic commerce depending on the level of urbanization and where the buyer and the online store can use different channels for the sale of goods, while the value of customer costs is also significantly affected by the weight of the product; thirdly, as statistics show that not all the shopping visits end with the purchase of the goods.
In this model [11] it is believed that the e-trade market geographically presents a specific area *Z* divided into *k* categories, depending on the level of urbanization and the distance of delivery of goods. T_k is the number of visits to online stores for the purpose of purchasing goods in two main channels of distribution in ecommerce: direct delivery of goods to the address of the buyer's home (Home deliveries - *HD*) or delivery to the nearest consumer point of delivery (Reception points - *RP*). The average load capacity of each of the sales channels (Channel Shopping – *CS*) goods CS_k^{HD} and CS_k^{RP}, is defined as the percentage of Internet store visitors using the chosen sales channel to buy the product. The values of the constants CS_k^{HD} and CS_k^{RP} depend on the category *k* to which the delivery point belongs [20]. Depending on the level of urbanization of *Z* region, it is customary to distinguish three main categories *k* [21]: the first, *central city zone* is the city itself and the assimilated suburbs; the second, *close periphery* – settlements that are located not far from the central city zone; the third, *far periphery* - settlements that are far from the central city's zone.
From this it is possible to determine, for a separate sales channel, the number of orders for goods *N* in online stores for two sales channels of each category *k*:

$$\left.\begin{aligned} N_k^{HD} &= CS_k^{HD} T_k \\ N_k^{RP} &= CS_k^{RP} T_k \end{aligned}\right\} \quad (2)$$

To carry out the simulation of the deliveries distribution at the address of the buyer's residence, it is necessary to analyze the travel routes. With this purpose, the results presented in work [18], which provide the characteristics of delivery services to the address of the residence and the corresponding routes, were used.
In electronic commerce, not all orders for the product finish with the purchase. The results presented in the paper [19] show that 53% of deliveries are completed with the purchase of goods, and in 47% - 3 deliveries correspond to 1 purchase. Then the number of orders for goods in electronic commerce, which ends with the purchase of goods *NO* for each sales channel, is [11]:

$$\left.\begin{aligned} NO_k^{HD} &= 0.53 N_k^{HD} + \frac{0.47 N_k^{HD}}{3} \approx \frac{2}{3}\left(CS_k^{HD} T_k\right) \\ NO_k^{RP} &= 0.53 N_k^{RP} + \frac{0.47 N_k^{RP}}{3} \approx \frac{2}{3}\left(CS_k^{RP} T_k\right) \end{aligned}\right\} \quad (3)$$

The number of delivery routes *M* at the residence address for each category *k* is defined as [11]:

$$M_k^{HD} = \frac{NO_k^{HD}}{m_k^{HD}} \quad (4)$$

where m_k^{HD} – the number of buyers' addresses on the route of delivery in the category *k*.
In order to determine the average distance of delivery of goods d_{ik}^{HD} to the certain *i*-thbuyer at the order, which ends with the purchase, it is necessary to divide the total

distance of travel D_k^{HD} by the number of routes of deliveries:

$$d_{ik}^{HD} = \frac{D_k^{HD}}{M_k^{HD}} \quad (5)$$

Using the formulas (2, 3, 4) we obtain an expression for calculating the average distance of delivery of the goods at the address of residence when it is purchased [11]:

$$d_{ik}^{HD} = \frac{3m_k^{HD} D_k^{HD}}{2\left(CS_k^{HD} T_k\right)} \quad (6)$$

When delivering the goods to the nearest point of delivery to the buyer, the consumer shopping campaign can be replaced by a visit to the nearest point of delivery, which ends with the purchase [22]. Then the number of routes to the delivery points can be defined as:

$$M_k^{RP} = \frac{NO_k^{RP}}{m_k^{RP}} \quad (7)$$

where m_k^{RP} - the number of consumers who are closest to the point of delivery of goods in the category *k*. In this case, the delivery route should be understood as either an individual order or a collective order of buyers who are located territorially closest to the chosen point of delivery of the goods.

By analogy with the case of delivery to the address of residence at the order, which ends with the purchase, the average distance of delivery of the goods to the *i*-th buyer d_{ik}^{RP} d to the collection point in the category *k* is:

$$d_{ik}^{RP} = \frac{3m_k^{RP} D_k^{RP}}{2\left(CS_k^{RP} T_k\right)} \quad (8)$$

where D_k^{RP} - the total distance of deliveries to various items of goods delivery[18, 22].

The average for the two distribution channels of goods the distance of delivery of the goods i to the buyer in the category *k* will be equal to:

$$d_{ik} = \frac{1}{2}\left(d_{ik}^{HD} + d_{ik}^{RP}\right) \times \times \frac{3}{4}\left(\frac{m_k^{HD} D_k^{HD} CS_k^{RP} + m_k^{RP} D_k^{RP} CS_k^{HD}}{CS_k^{HD} CS_k^{RP} T_k}\right) \quad (9)$$

And the average for all categories *k* the distance of delivery of goods inelectronic trading will be determined by the formula [11]:

$$d_i = \frac{1}{3}\sum_k d_{ik} \times \times \frac{1}{4}\sum_k \left(\frac{m_k^{HD} D_k^{HD} CS_k^{RP} + m_k^{RP} D_k^{RP} CS_k^{HD}}{CS_k^{HD} CS_k^{RP} T_k}\right) \quad (10)$$

Depending on the charging zone (the goods delivery distance) and the weight of the goods, the cost of delivery is different [23]. It should be noted that for the distribution channel of goods at the address of residence in the central city area, for the delivery of goods mainly used not postal service, but the delivery service, but the cost of delivery of goods by courier service is almost the same as charging “Deutsche Post DHL” for the zero tariff zone. Therefore, for the purpose of determining the functional dependence of the value of the customer costs on the distance of delivery and weight of the goods, the tariffs of “Deutsche Post DHL” [23] are used. This supplier of services has been selected for the reason that today it is one the most widely used in e-commerce provider to deliver goods to customers, both at the address and to the point of issue.

The function of customer transaction costs that obtained from the data [23] is a plane in the coordinates of the distance of delivery *d* and the weight of the product *w* and is described by the dependence:

$$CC = \left(a_1 w + a_2\right)\left(b_1 - d\right)\left(b_2 - d\right) \quad (11)$$

where a_1 and a_2 are coefficients proportional to the value of the tariffs t of the goods weight; b_1 and b_2 - coefficients related to the location of the buyer in the trading market space.

The dependence (11) is in good agreement with the results of work [15, 16], in which customer transaction costs are also described by a quadratic function from the distance between the store and the buyer. In formula (10) it has been found the ratio for the average delivery distance is clear that in each case it is necessary to take into account the buyer's location.

In electronic commerce, the average delivery distance determines the actual location of the estore in the trading market in relation to the consumer. The distance to a store is the difference between a buyer and a store location. Thus, in the “linear city” model [14], while taking into account the obtained modeling results, customer transaction costs can be represented by the function of the distance of delivery *d*, the buyer's location *x*, the weight of the product *w* and the tarification *t* as follows:

$$CC_i = tw(x_i - d_i)^2 \quad (12)$$

Taking into account (10) the customer transaction costs expression (12) can be written as [11]:

$$CC_i = tw\left(\begin{array}{l} x_i - \frac{1}{4} \times \\ \times \sum_k \left(\frac{m_k^{HD} D_k^{HD} CS_k^{RP} + m_k^{RP} D_k^{RP} CS_k^{HD}}{CS_k^{HD} CS_k^{RP} T_k} \right) \end{array} \right)^2 \quad (13)$$

3. RESULTS AND DISCUSSION

In this investigation, we focused our attention to influence of introduction of the collective product delivery routes and the level of consumer conversion rate on the customer transaction costs in electronic commerce. Since payment for delivery of goods to the buyer is made according to services supplier tariff, the question arises: how the customer transaction costs can be adjusted in electronic trade at the same fixed tariff rates for the cost of the goods delivery.

On our opinion, first of all, due to the introduction of appropriate collective routes of goods delivery, at several addresses m_k. at the same time and increasing conversion rate level of buyers. Increasing the number of delivery addresses per route can result in a lower delivery costs for per buyer.

The obtained dependence (13) allows us to analyze the influence of collective orders m_k on customer transaction costs for two channels of goods sales for each category k. The tarification coefficients and statistics values on the volume of delivery to the individual address, the volume of delivery to multiple addresses per trip, number of delivery addresses per route, and the average distance of goods delivery required for the simulate the impact of the collective routes delivery introduction on the transaction costs for per buyer were taken from [18, 22, 23].

Table 1 shows the simulation results for customer transaction costs in e-commerce for different categories of territorial urbanization. The calculation was performed by the formula (13). In formula (13) we consider that at least one order was made for each of the goods delivery channels. A reduction (Table 1) of the customer transaction costs *CC* in comparison with individual delivery costs is connected with taking into account in calculation introduction of collective delivery routes. It was found the that reduction of customer transaction costs *CC* involves an optimizing the collective routes of goods delivery. The maximal effect is observed for central city zone (see Table 1), where it is possible to carry out an effective territorial combination of the addresses of buyers in the delivery route.

Table 1 The values of customer transaction costs in e-commerce, received in the framework of the presented model, taking into account the collective routes of goods delivery for different categories of territorial urbanization

Specifications	Central city zone		Close periphery		Far periphery		Average value	
	CC, EUR	***Individual delivery costs, EUR***	***CC, EUR***	***Individual delivery costs, EUR***	***CC, EUR***	***Individual delivery costs, EUR***	***CC, EUR***	***Individual delivery costs, EUR***
Weight category A (up to 10 kg)	0,41	1,27	2,23	2,54	4,62	8,88	2,42	4,23
Weight category B (from 10 kg to 100 kg)	1,16	3,62	6,37	7,25	13,20	25,36	6,91	12,08
Weight category C (more than 100 kg)	2,55	7,97	14,01	19,93	21,79	39,86	12,78	22,58

From the resulting expression for customer transaction costs *CC* (13) also follows their dependence on the number of views to buy the product T_k, or in other words the conversion rate. The conversion rate is the ratio of the site visitors number who placed an order to the total number of site visitors over a given period of time [24]. For Western countries, on average, the conversion rate for online shopping is close to 10% of total views [25]. There are different methods for determining conversion rate [26-28], for example, the number of purchases per 1000 views - if there were 10,000 visitors to an online store in one day and 1000 of them bought the product, then the conversion rate is 10%.

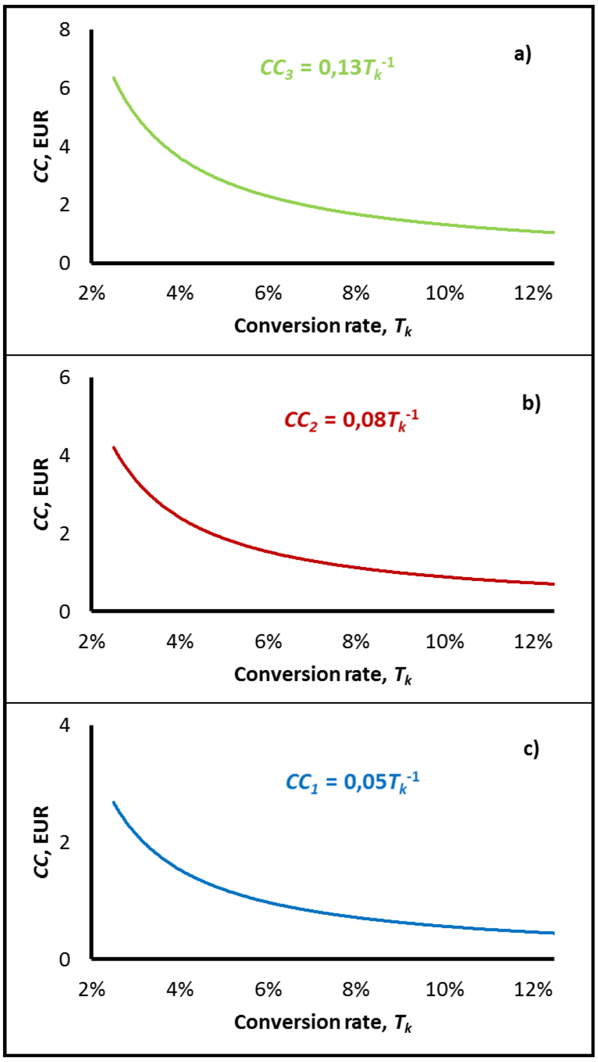

Figure 1 Customer transaction costs dependencies on conversion rate values $CC=f(T_k)$. a) k=3, b) k=2, c) k=1

Investigation of the influence of website visitors conversion on customer costs is important to online marketers in terms of increasing business profitability, as customer costs is an important factor in shaping consumer priorities that can drive to increasing of online store product sales [29-32]. Increasing the conversion rate increases the purchases number in an online store, which can reduces the total customer costs due to increasing the number of customer addresses on the route of goods delivery, on the other hand, reducing the customer costs makes it more attractive to buy goods in this online store and help to increasing the conversion behavior rate of site visitors. Using data [18, 22, 23], formula (13) allows us to investigate the effect of conversion rate T_k on the customer transaction costs CC. The obtained calculations results are presented in Figure 1 and Table 2.The dependencies are shown in Figure 1, shows that consumer transaction costs are decreasing with increasing conversion rate values differently for each of territorial urbanization categories k. The obtained dependencies $CC=f(T_k)$ can be explained by the fact that the increase in the conversion rate values increases the number of goods purchases in the online store, which allows to reduce the customer transaction costs by increasing the number of customer addresses on the goods delivery route. The maximum effect is observed for the central city zone (k=1) where it is possible to carry out effective territorial combination of buyers' addresses on the delivery route.

Table 2 The average customer transaction costs with different conversion rate values obtained by the calculation according to expression (13)

T_k	*CC*, EUR		
	k=1	k=2	k=3
2%	2,68	4,21	6,34
4%	1,34	2,11	3,17
6%	0,89	1,40	2,11
8%	0,67	1,05	1,59
10%	0,54	0,84	1,27
12%	0,45	0,70	1,06

4. CONCLUSION

This study reports calculations results on the customer transaction costs simulation in e-commerce. When calculating the values of customer transaction costs in e-commerce it is considered that at least one order was made for each of the goods delivery channels. The simulation of customer transaction costs in e-commerce show that they can be significantly reduced by optimizing the delivery routes and increasing conversion rates. The obtained results are discussed here with an emphasis on the introduction of the collective product delivery routes and the increasing the level of consumer conversion rate. The reason for this can be attributed to the fact that the increasing the number of delivery addresses per route can result in a lower delivery costs for per buyer. A theoretical model where customer transaction costs are the function of the views number of online stores for purchasing goods purpose, the average load for each of the channels of goods sales, the number of buyers addresses in the goods delivery route, the total distance of delivery routes, weight of goods and tarification coefficient is employed to test the validity of this assumption. It should also be noted that reducing customer transaction costs increases the ultimate consumer usefulness of purchased goods and creates additional benefits in a competitive e-commerce market. On the basis of these studied it seems reasonable to conclude that the presented model [11] can be applied for simulation of the customer transaction costs in e-commerce when developing effective sales strategies.

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