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Assessing the Impact of Population Mobility on Consumer Expenditures while Shopping

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Abstract

Functioning of transport systems is based on the evaluation of related technical parameters. Longer transit has negative impact on characteristics of citizen's life activity. Longer travel time, leads to the decreasing leisure time, rising of fatigue and other negative consequences of the humans. From the society perspective, the optimal technological parameters of transportation can be determined considering the enterprises incomes, transport companies costs on the organization of process and value costs of society as a result of the transportation process. The research aim is to measure the transportation costs among passengers on purchase purpose movement. Assessing the monetary impact of transport, non-transport and Internet option while making purchase on different distance can be define the optimal transportation technologies parameters from the perspective of society.

Keywords: Consumer behaviour; Access to transport; Urban Mobility; Consumer Expenditure

1. Introduction

Movement of goods and people in the process of purchasing leads to the emergence of transport and pedestrian flows. On one hand, increase in the levels of motorization has led to significant increase in the population mobility. On the one hand and increase in the range of goods and unevenness of their transportation has caused increase in urban freight based traffic flow. Thus requiring development of methods of urban logistics and special methods of survey data processes aimed at efficient management of all flows (Hounwanou et al., 2016). Therefore, the purpose of such

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research is to minimize cost of commute, cost of goods deliveries to end-consumers and external cost of environment due to these two categories, ultimately maximization utility for society.

Logistics demand by the end-consumers is based on multiple factors. However, regardless of these factors each choice of end-consumer results in expenses due to the choice. Expenses during shop visits, stores, malls etc. (customary method) are associated with travel time (Becker, 1965), time cost (Kotler & Armstrong, 2010), and energy expenses due to movements to the shop and back (Halkin, 2018). E-commerce saves time and is not so tiring, but there are additional costs associated with delivery. Every day end-consumers select a rational way for purchases depending on various reasons generating urban goods flows and logistics channels for goods distribution. Influence on last-mile channel selection by end-consumers affects uni-directional goods flow distribution. Therefore, we see different ways of selling, discounts and special offers to attract customers to these channels, today. All this, is being done to satisfy personal needs of the particular buyer. From other side, logistics and marketing technologies can affect attraction of any distribution channel i.e. applying "just in time" technology can decrease price of goods, which can stimulate demand. Everyday delays decrease number of orders and customer flow. Logistics based profit depends on turnover of channel. Creation of attractive conditions for channel will lead to higher probability for the intended choice, thereby, increasing the turnover. Therefore, a technology, which will be effective for both participants (clients and logistics system) should be applied. However, due to global recession and falling purchasing power of customers, retailers have started to reduce the order quantity. In such a condition each of the distribution channels become unstable or episodic. Influence of these factors have adverse impact on logistics system functioning.

The municipality studied has high concentration of multiple flows: material, passenger-grain flows, transport, trade, finance, management, waste and others. The increase of density of these flows and their distribution over time and zones of cities is uneven. The concentration of flows is heavy in the central zones, distribution hubs, urban highways and main intersections of cities. This causes overload of urban network, the occurrence of congestion in flow of necessary resources over the city, complicates the public transport functioning, and adds to the external costs of logistics. The rational organization of material and social flows, ensuring the maximum orientation of the entire production and economic activity of municipal enterprises to the satisfaction of the needs of the inhabitants, is one of the priorities of the municipal policy (Russo & Comi, 2016).The development of effective schemes that could be used to promote material flow, both for logistics system participants and the consumers, along with reduction of impact on the functioning of other systems in the city, is one of the priority tasks of research today.

In conducting research on the cost to the society while purchasing various products, it is necessary to pay attention to the diametrically opposite objectives of all participants in the processes of production, delivery, consumption and product support: logistics is profit-oriented, the consumer to reduce costs and increase the service, local authorities to resolve the problems of the city's residents and business, as well as tax collection to provide it. With the interaction of the systems "Logistics" - "Consumer" - "City" the greatest effect in their operation will be achieved by taking into consideration the parameters of each of the systems (Fig.1).

The urgency of effective research and its functioning for the society is due to a number of factors. First, the need for distribution of household income between purchase of various goods and services that would maximize the satisfaction. In this case, based on consumer behaviour are the income and substitution effect and the law of diminishing marginal utility. Second, a constantly increase in the economic value of time of society. Thirdly, both for the organization and for the end users, it is important to address the problems associated with benefits, costs and risks when the market is saturated by most types of products. When conducting research on consumption costs when purchasing various material flows in different logistic systems, it is necessary to compare consumer spending with logistics in order to determine the overall efficiency of the functioning of the "Consumer" - "Logistics" - "City". The problem is in complexity of assessing joint efficiency of the interaction of all stakeholders.

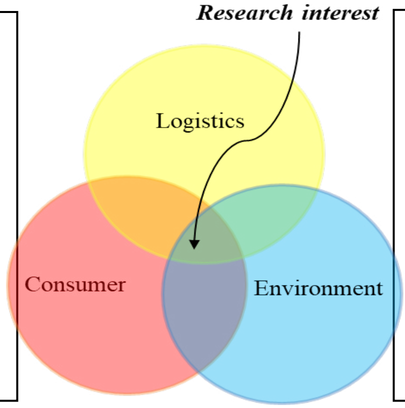
This research concentrates on evaluating and assessing the consumer's time in monetary terms while shopping. To achieve this goal the leisure time costs have to evaluated; the experiments of consumer movement to shops and back have to be made; The regression models that described time of consumer's trip to shops and back for purchase process have to be made; Assessing the average monthly time spends of end-consumers in monetary expression have to be made.

Concepts and technologies of logistics, for customer service: Requirements/resource planning (Russo & Comi, 2016); Reverse logistics (Brix-Asala, Hahn, & Seuring, 2016), Just-in-time (Borghesi, 2017); Demand driven Techniques/Logistics (Hensher & Figliozzi, 2007); Quick response (Lowson, King & Hunter, 1999); Lean Production and Logistics (Lamming, 1996); Efficient Consumer Response (Reyes, & Bhutta, 2005); Vendor Managed Inventory (Bookbinder, Gümüş, & Jewkes, 2010); Time-based logistics (Muilerman, 2001); Green logistics (Mesjasz-Lech, 2016); Customer Focused Manufacturing (Gasser, 2002); Value added logistics (Rajagopalan, 2016); The Customer-Driven Supply Chain (Jüttner et. al., 2007).

Consumer Choice Models: Huff (1963), Lucas Model (Applebaum, 1965), Nakanishi & Cooper Method (1974); Model of the Competing Destinations Model. Foteringham, (1983); Model Multinomial Logit Model. McFadden, (1974); Model Rust, Donthu, (1995)

Methods of study of human expenditure:

- Estimates of the cost of time: Becker, (1965); Galkin A., et. al. (2019)
- Purchase Costs Estimates: Russo & Comi, 2012
- Fatigue estimates: Jorgensen, 1989; Seidman, 2006.



Consumer environment:

Rust, Donthu (1995); Colome, Lourenco and Serra, (2003); Reilly (1931); MAXCAP model: ReVelle, (1986); Colomé, Lourenço & Serra, 2003); Paroli & Maraschin, (2018).

Methods of allocation and selection of logistic infrastructure:

Taniguchi et al., (1999); Olkhova, Davidich, Roslavtsev & Davidich, (2017) Litomin, Tolmachov, Galkin, 2016).

State policy in the field of transport:

- Time windows: Comi, Buttarazzi, Schiraldi, Innarella, Varisco, Rosati (2017)
- Territorial zones: Nuzzolo, Comi & Papa, (2013)

Fig. 1 – Research goal

2. Methodology

2.1 Total costs of consumption

Research indicates various methods for evaluating consumer's costs and the composition of such costs. This in turn complicates the calculation and brings ambiguity in the interpretation of the composition of consumption expenditure. The problem is also the integration of consumer parameters in the logistics system, and as a result complicates the possibility of determining the impact of a person or group of people with similar parameters on the results of the operation of the logistics system. The indicators for assessing the operation of the logistics system and society as a single system also need to be improved.

The costs of visit by residents of the *w*-th neighborhood of the *z* area that visits the *j*-store (Galkin et al., 2017):

$$\Theta_{z\omega j}^{total} = \Theta_{1\_z\omega j} + \Theta_{2\_z\omega j} + \Theta_{3\_z\omega j}, \tag{1}$$

Where ω – number of consumer's areas, $\omega = 1, 2,\ldots, \omega$; j – number of stores in the trade urban zone, $j = 1,2, \ldots, J$; z – number of trade urban zone, $z = 1,2, \ldots, Z$; $\Theta_{1\_z\omega j}$ – the cost of purchasing a product at the *j*-store by a consumer living in the ω -th zone in the *z*-th area of service, EUR; $\Theta_{2\_z\omega j}$ – the cost estimate of human time expenses during purchases that residence in the ω-th zone in the *z*-th area of service in the *j*-store, EUR; $\Theta_{3\_z\omega j}$ – the cost estimate of the human's energy costs value in the purchases process in the ω -th zone in the *z*-th area of service of service in the *j*-store, EUR.

Scientists assess the part of the time spent on the purchase (time on the road) in value terms. The buyer can deliver the goods in the traditional way, that is, independently, or to get them at house via the delivery. Thus, in the traditional sense, for a buyer, the full price of a product includes travel expenses from the place of residence (or work) to the store and the cost of its time for the purchase of goods, the cost of time.

2.2 Monetary expression of time value

The time spent by buyer on purchases is a cost-generating indicator. Time is divided into: sleep (rest), work and leisure time. If sleep is a biological need of an individual, and work is necessary for existence in society, then leisure time is the time of self-actualization, self-development of a person, and others.

Specialists consider the leisure time as good, because it is necessary for the consumption of all other goods, and since the total time is limited to workers, then each hour of labor reduces the leisure time (Becker, 1965). According to its properties, leisure time corresponds to the products of material production. On the basis of this, it can be argued that the result of the purchasing process is a specific product – the time resource (free time) that is produced by the transport system or trade services and which is obtained by purchasers when making purchases with the current parameters. The specificity of leisure time consists in the fact that it has no material content, but only creates the preconditions for obtaining a positive effect in the future when used by buyers. The function of cost estimation of human time expenses for the implementation of the purchase process, depending on the parameters of the trading zone:

$$\Theta_{2\_zwj} = T_{z\omega j}^{TS} \cdot C_{z}^{cons}, \quad (2)$$

Where $T_{z\omega j}^{TS}$ – time spent on purchases, hours; C_{z}^{cons} – the cost of an hour of leisure time of the consumer in *z*-area, EUR/hour.

The methodology indicates that a person spends part of his time at work (8 hours), the rest is spent on the rest (sleep), cooking and eating (8 + 2). If subtract this time (18 hours) from 24 hours, then the time received is leisure time (Grigorova et al., 2015):

$$C_{t}^{hour} = \frac{\bar{S}_{pc}}{\Phi_{ctf} - (\Phi_{wtf} + \Phi_{ftf})}, \quad (3)$$

Where $\bar{S}_{pc}$ – average salary of people in the research area, EUR; Φ_{ctf} – hourly fund of calendar time per month, hours; Φ_{wtf} – monthly fund of working time, hours; Φ_{ftf} – monthly fund of leisure time, hours.

Part of monthly leisure time is time for purchase, cinema, theaters, etc. Recently, in countries with a developed market economy, all forms of development of various forms of after-sales services to customers, such as the delivery of purchased goods to home are increasingly being developed. Another component of consumption expenditure can also be measured in terms of expenses (public and private transport costs, packaging materials costs, etc.) (Arndt & Gronmo, 1977). Thus, in the traditional sense, for a buyer, the full price of a product includes travel expenses from the place of residence or work to the store and the cost of its time for the purchase of goods, the cost of time.

2.3 Technological process of purchase

The time of connection directly depends on the speed of travel. The estimated speed pedestrian of movement depends on many factors. Studies indicate the following speed indicators for different categories of people (). Otherwise, the specialists determine the different average speed of transport connections for different cities and different modes of transport. Its boundaries range from 18-50 km.h^{-1}, depending on the city, the hour of the day and a number of other factors (Russo & Comi, 2012). In assessing the time consumed by the buyer you need to consider not only the trip time, but also the time for trade service:

$$T_{z\omega j}^{TS} = t_{t}^{walking} + t_{t}^{traveling} + t_{t}^{TS}, \quad (4)$$

Where $t_{t}^{walking}$ – walking time to store and back, h; $t_{t}^{traveling}$ – moving time on transport (bicycle, cars, urban public transport, ect.) to a store, h; t_{t}^{TS} – trade service time (inside of the shop), h.

The average actual cost of customers' time is determined on the basis of chronometric observations in and out the store by the elements of purchase process time (waiting for service, consultation, expectation of calculation, calculation, receipt of goods, etc.).

3. Results

3.1 Collecting the data

Survey was conducted to find the initial values of the parameters of consumers and stores. The essence of the study was visiting the consumers of shops in the trade area and fix the selected consumer's indicators: time for trade services; number of meters passed; number of purchases per visit; "average check"; physiological parameters (height, weight, age) and parameters of stores: the number of cash and cash units; number of staff; assortment; number of people in a queue; price of goods; the number of purchases per trip, size of the shop, number of functioning cashiers. Service area is shown in Fig. 2 and 3.

By type of a store and its choice and time of movement towards it are connected. Separate three zones of retailers: trade area, district, regional (city). The average travel time to them will also be different. Moving to a sellers can take place in different ways: on foot, bicycle, car, public transport or in a combination ways. For the first type shopping area where 70% of purchases are considered in the study, 80% is by foot, 19% using own cars and less than 1% by other means.

Figure 2 – Trading area

– shopping facilities included in the trading area;
– Plots with multi-storey building 9 floors;

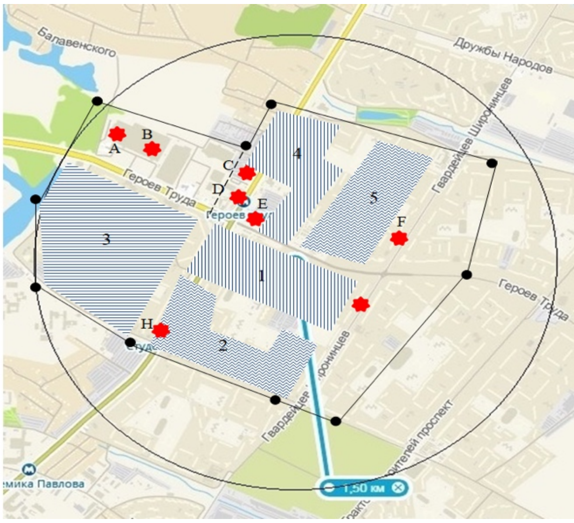


Figure 3– Trading area with adjustment

– Plots with multi-storey building 9-16 floors;
– Plots with multi-storey building 9-12 floors.

The number of meters passed in one trip to the store, the time of one trip to the retailer was measured via the Xiaomi Mi Band 2 equipment, where the height, weight, average length of the step are add.

3.2 Data variation range

The purpose of this subsection is to identify factors (and the range of their variation) that affect the total costs of the consumer when making purchases. The result of the interaction is the time spent in the store and on the way to it. The data variation range is shown in Table 1.

Table 1. Data variation range of models

Parameter	Factors	Average	Dimension	Min value	Max value
Q_n	The number of purchases (n) per visit in *j*-th store	15	units	3	27
N_{cst_j}	the number of customers in queue (line) at the cashier in *j*-th store, buyers	3	buyers	0	6
L_{m_ij}	The distance from home to retailer and back	350	meters	150	2250
N_{csr_j}	the number of cashier functioning at the store in *j*-th store	4	units	7	1
S_m	The size of retailer in *j*-th store	200	m^2	80	320
A	Age	31	years	27	35

In this paper we consider only purchase in walking distance. Most of the food purchase (grocery, butcher, discounters, etc.) are situated near its consumers. There big challenge between them to get demand. Especially it's actual for high-income countries. We had made research in Kharkiv (Ukraine) which is been part of them according to the World Bank. The whole list of experiments results are shown in the Table 2.

Table 2 – Analysing the visits to various stores

Experiment number	Number of purchase per trip, units	Overall purchase by shop visit, euro	Walking distance per trip via Mi Band 2, m	Number of cashier, units	Number the people in line, people	The retailer size, m2	Purchase time, min
1	2	3	4	5	6	7	8
1	8	3,80	380	3	0	150	9
2	7	8,07	3184	8	3	150	8
3	27	13,72	3849	4	2	300	25
4	19	35,37	5186	6	5	300	30
5	8	10,96	3902	2	1	200	16
6	8	7,73	4712	7	3	150	9
7	9	17,22	1321	2	0	100	6
8	9	6,75	1744	4	2	150	8
9	8	10,21	719	2	1	120	5
10	7	8,05	3671	5	0	150	4
11	7	3,69	1027	8	1	150	8
12	7	4,11	5123	6	3	200	9
13	5	8,33	351	3	0	75	4
14	3	1,83	312	3	0	100	3
15	7	3,30	1299	3	2	120	6
16	6	5,47	1381	2	2	120	8
17	24	11,72	1195,2	4	3	150	18
18	17	24,46	1557,6	3	4	300	23
19	7	8,39	820,8	2	2	100	10
20	8	9,30	1524	2	0	75	11
21	7	12,02	1570,8	1	1	75	10
22	9	8,04	1556,4	2	2	75	13
23	7	6,94	1109,4	2	3	100	8
24	7	5,66	855,6	2	0	120	7
25	7	7,20	1117,2	3	2	150	9
26	7	3,84	836,4	2	1	100	8
27	4	7,37	778,8	3	1	100	6
28	3	2,29	1446	2	1	75	4

3.3 Modelling the walking time to store and back

The parameters characterizing the time spent in the store (trade service time):

$$t_t^{walking} = f(L_{m\_ij}) \tag{5}$$

where L_{m_ij} – distance from home to shop, km;

Overall walking time dependence on distance is presented in fig. 2

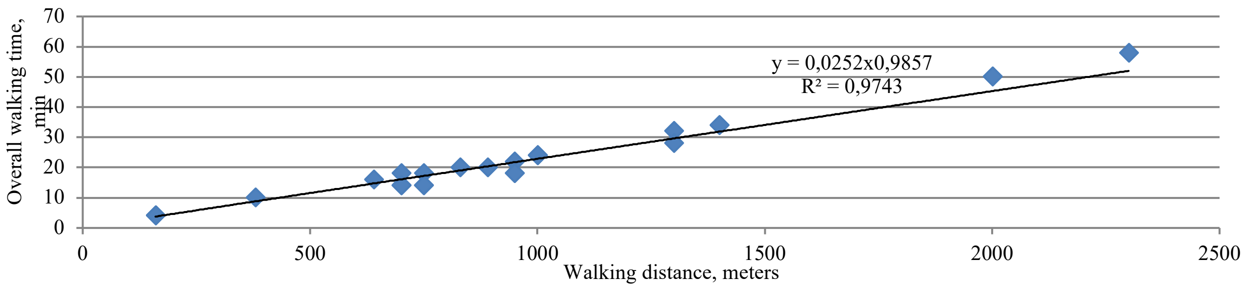


Fig 2. Overall walking time dependence on distance

The overall walking time depends on distance is presented as:

$$t_t^{walking} = 0{,}0252 L_{m\_ij}^{\;0{,}9857}, \tag{6}$$

Increasing the distance directly increase the movement time and vice versa.

The decision to choose the route of movement requires the end-consumer to compare possible options, based on management experience, psycho-physiological state, personal characteristics. Carried out by the authors showed that the probability of choosing the i-th route for movement can be formalized as follows:

$$Ver_i = f\,(V_i\,/V_{krat},\, L_i\,/L_{krat}), \tag{7}$$

Where $V_i\,/V_{krat}$ – the ratio of the speed of movement along the *i*-th route to the speed of movement along the shortest route; $L_i\,/L_{krat}$ – the ratio of the length of the *i*-th route to the length of the shortest route.

3.4 Modelling the trade service time

The parameters characterizing the time spent in the store (trade service time):

$$t_t^{TS} = f(N_{cst\_j}; Q_n; S_j; N_{csr\_j}) \tag{8}$$

where: N_{cst_j} – the number of customers in queue (line) at the cashier in *j*-th store, buyers; S_j – the size of shop in *j*-th store, m^2; Q_{nj} – the number of purchases (n) per visit in *j*-th store, units; N_{csr_j} – the number of cashier functioning at the store in *j*-th store, units.

We used the Statgraphics Centurion for evaluating results and obtained next model of average time been in store:

$$t_t^{TS} = 0{,}04 \cdot S_j + 1{,}22 \cdot N_{cst\_j} - 0{,}69 \cdot N_{csr\_j} + 0{,}54 \cdot Q_{nj}, \qquad (R^2 = 95{,}98\%) \tag{9}$$

Modeling the trade service time on factors is shown in fig. 3.

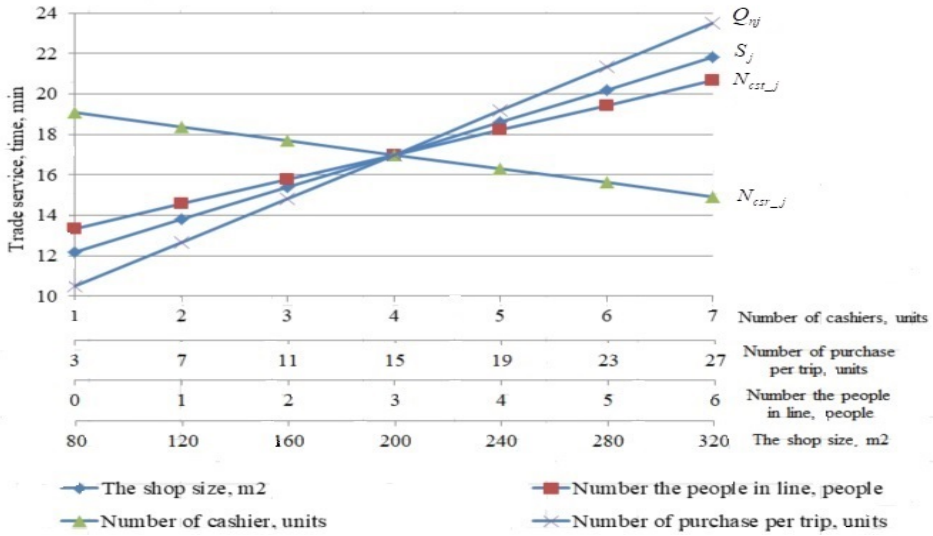


Fig. 3. Modeling the trade service time on factors

Table 3 shows general analysis of the factors.

Table 3. Factors analysis table

Parameter	Estimate	Standard T Error	Standard T Statistic	P-Value
Size of retailer	0,0404298	0,0118402	3,41461	0,0023
Number of customers in queue	1,21669	0,483145	2,51826	0,0189
Number of cashier functioning at the store	-0,691271	0,277379	-2,49215	0,0200
Number of purchases (n) per visit	0,543002	0,13034	4,16606	0,0003

According to the fig. 3 and model (8) we can conclude that the size of shop, the number of purchases per visit, the number of customers in queue increase the purchase time, and the number of cashier functioning at the store is decreasing it. Further analysis will made according to average income of consumers in Ukraine.

3.5 Research costs due to purchase

Consumer's expenditures while shopping on distance to a shop modelling is present at fig. 4.

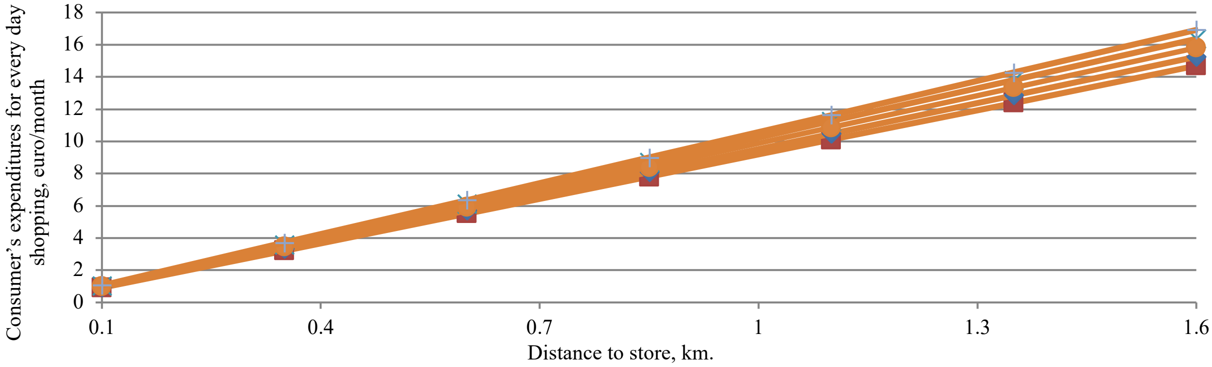


Fig. 4. The dependence of the value of free time on distance to store, at different wages of buyer:
– 400 euro; – 600 euro; – 800 euro; – 1000 euro; – 1200 euro

As the monetary value of leisure time per month is increased with distance to shops. For figure we can see significant changes of these parameters in almost 15 times between min-max values. The consumer's income affects monetary costs of buyer during the month on 15 %.

Another main factor, which has significant influence on the purchase is a frequency. To buy a lots a products once per week or make purchase every day and spend less time in shop but much more time in walking. We modeling situation when consumers made purchase one week and going to farthest shop which is probably cheapest. In other option evaluate results with every day buying (365 times per year), but in nearest shop, which can be most expansive. The intermediate options were also present at the fig. 5.

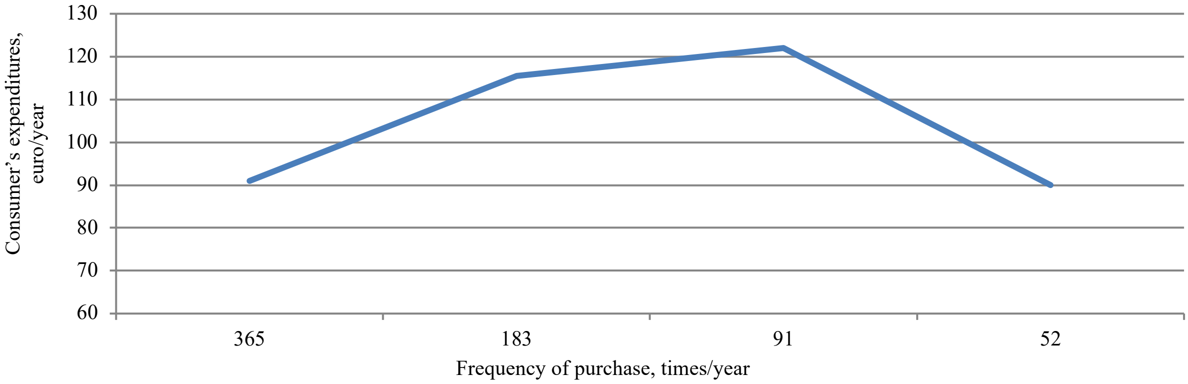


Fig. 5. Consumer's expenditures on frequency of purchase

Costs of purchases depend on the amount of material flow that is purchased at a time. If the annual need for products is broken down by the number of trips to a shop in a year in accordance with established norms, then you can calculate the average amount of material flow that will be sold to one consumer in one trip. Considered options when the consumer goes to store every day – 365 times a year, once every two days – 183 times; 2 times a week – 92 times a year; and once a week – 53 times.

3.6 Probability of visiting stores

The calculation of the matrix of displacements (O-D matrix) of end-consumers will be calculated by (Galkin et al., 2017), the results of calculations are given in Table 4. Based on the data obtained and using dependence (1), it is possible to determine the volume of demand for each individual store based on the functioning of three independent systems: consumer, city, logistic system. By including the parameters of each of the systems in a single model – determining the probability of visiting the retailer, it was possible to investigate the change in demand for the variation parameters of each of the systems.

Table 4 – OD matrix

Store	Consumers' time costs when shopping, hours					Time consumed by the consumer in monetary terms, UAH					Probability demand distribution, %				
	Zone					Zone					Zone				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
A	1,00	1,05	0,73	1,05	1,05	18,33	19,25	13,29	19,25	19,25	10,20%	10,20%	12,90%	10,30%	10,50%
B	0,95	1,00	0,70	0,99	1,00	17,42	18,33	12,83	18,06	18,33	10,60%	10,50%	13,20%	10,70%	10,80%
C	0,60	0,65	0,70	0,67	0,78	11,00	11,92	12,83	12,19	14,21	14,00%	13,80%	13,30%	13,70%	12,70%
D	0,72	0,75	0,72	0,69	0,74	13,11	13,75	13,11	12,56	13,57	12,70%	12,70%	13,00%	13,50%	13,20%
E	0,53	0,63	0,75	0,63	0,68	9,63	11,55	13,75	11,46	12,47	15,20%	14,10%	12,60%	14,30%	13,80%
F	0,79	0,90	1,05	0,62	0,55	14,48	16,50	19,25	11,37	10,08	11,90%	11,30%	10,20%	14,30%	15,70%
G	0,65	0,73	0,98	0,74	0,77	11,92	13,38	17,97	13,57	14,12	13,40%	12,90%	10,70%	12,90%	12,80%
H	0,78	0,60	0,63	1,05	1,05	14,30	11,00	11,46	19,25	19,25	12,00%	14,50%	14,10%	10,30%	10,50%

Using the proposed method, one can estimate the total expenses of the buyer, household, residents of a separate home, the urban zone when visiting any retailer. The expenses of the logistics system are an integral part of the promotion of the material flow to the end-consumer. The proposed model can be used for evaluating logistics system efficiency according to external consumption system data. Give practical advice for improving logistics systems according to consumer's choice and behavior. The result of the promotion is the added value which is reflected in the price, end-consumer time reduced or flows associated with purchases decreasing in city.

Conclusions

A buyer faces with selection problems that determine his/ her consumer behaviour. Firstly, the need of distributing (dividing) existing household income between purchasing various goods and using services that maximize their needs. In this case, the basis of consumer behaviour is the effect of income and substitution, as well as the law of marginal utility. Secondly, consumer's leisure time value is increased. The time the buyer spends on purchasing a product is an expense producing a value that has its value. The cost of free time of citizens depends on the distance from the point of sale of the product to the buyer's location. Thirdly, for end users, solving problems associated with the benefits, costs and risks of saturation of the market by a large number of products is important. The presence of a large number of interchangeable and complementary goods complicates the buyer's choice and increases the time to make purchases. Quantity and variety of goods, their price, ultimately determine the choice of stores, leisure time spent in it and the cost of purchases.

To reproduce the plausible behaviour of the pedestrian flow model, processing of a large array of information from other disciplines - sociology, psychology, and others. Understanding this information will enable you to work with two upper levels of pedestrian behaviour. For modelling the operating level often based on various physical models, representing the human stream, for example, as some kind of substance consisting of large molecules or figures on a chess field. The purpose of this presentation is to find such a model that will be easy to implement as much as possible, but it will reproduce the "realistic" behaviour of the human stream, which will be close to the results of the experiment and can be repeated more than once.

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