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URBAN ENVIRONMENT INFLUENCE ON DISTRIBUTION PART OF LOGISTICS SYSTEMS

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Abstract: *The irregularities of evolutionary development, continuous improvement of environmental component into transport and raise many unsolved problem in the fields of transport in logistics systems and material flows management. The city parameters analyses had highlighted connections with transport services technology. Also the distribution stage of the logistic chain, which consists of following market participants: incoming material flow, retailers and Transportation Company (carrier) in different cities has been considered. Transportation service is made by road transport. The paper compares results of transportation servicing in different cities and logistic chains with same technology. As performance indicator net present value has been used. Existing criteria for evaluating the effectiveness of distribution of material flows does not sufficiently take into account the time value of money and possible options for investment, so when estimating the performance of servicing of business investment indicators should be used. Paper should elucidate the impact of cities on the transport service efficacy. Practical suggestions on logistics system functioning and transportation service of retailers in urban area have been proposed. Obtained results discovered overall impact of city's parameters (density of streets and roads network' irregularity factor; automobilizationlevel; urban square; scheme of road network; city radius) on logistics according to model which include more than 50 parameters and allows finding regularities of changing logistics efficiency on them.*

Key words: *logistics channel, material flow, transport planning cities, automobilization level, retail network.*

1. Introduction

The processes of globalization pose new challenges for logistics. Continuous improvement of logistics services is caused by increasing range of goods and conditions of their carriage. Entering lots of international companies with their products on Ukrainian markets leads to the feasibility to find effective ways for planning logistics process in cities, with same tasks are facing domestics businesses. Increasing demands of transportation services caused by goods range and conditions of their carriage is growing and it leads to necessity of improving approaches of transportation service to material flows (Zacharia & Mentzer, 2004). Lot of markets of these goods makes to search best way to distribute them in different areas.

System approach exploring the transportation process allowed identifying groups of factors influencing its managing: the factors characterizing the transportation technologies (Vorkut, 1986; Nikolin, 1990), technology of cargo handling operations (Davidich, 2006), the conditions (environment) motion (Gulpenko & Gaysenok, 2011; Gajewska, 2013; Abdel-Aty, Kitamura & Jovanis, 1997) vehicle (Vorkut, 1986 ; Davidich, 2006) and the driver (Davidich, 2006; Abdel-Aty, Kitamura & Jovanis, 1997). Simultaneously, despite a variety of existing methods and factors, which they considered have been insufficiently studied an environment and conditions under which the transportation process occurs (Garver, Williams, Taylor, & Wynne, 2012). To these researchers include next: the type of road and road surface, weather conditions, time of day, the conditions of service on the route, including the availability of gas stations and others (Prasolenko, Lobashov & Galkin, 2015; Lobashov, 2010) Fig. 1. In addition to the planning and organization of transportation in an urban environment is also requires consideration of the parameters of the city itself: area, population size, range, level of automobilization, road network density, transportation planning scheme and others (Xie & Levinson, 2011;Cherepanov, 1970), the influence of which are insufficient research. These rapidly varying factors have different effects on the efficiency of the transportation process.

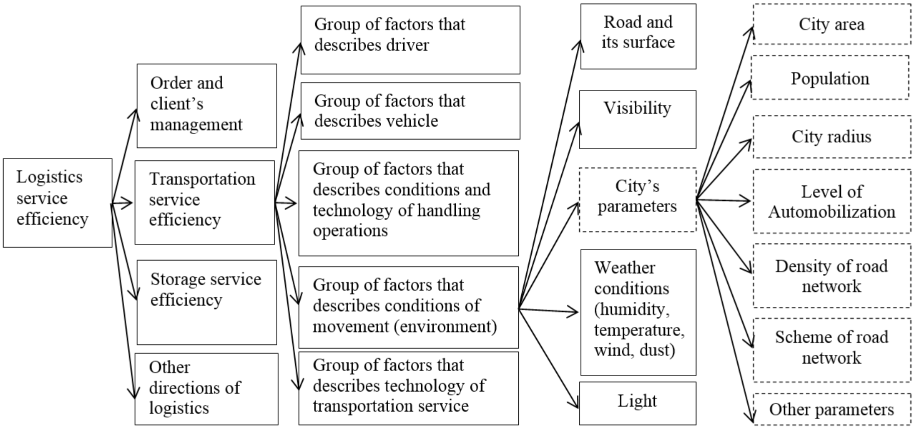

Fig. 1. Factors that determine transport functioning in logistics system

However, role and place of urban parameters in the overall logistics, is still not enough detached and defined. Tasks of the planning of the transportation process, daily schedules of customers' service, ect, are disregarding urban component, which can significantly affect the efficiency.

The paper explores the influence of city area, population size, range, automobilization level, the density of the road network, transportation planning scheme and others (He, Liao, & Wang, 2017) on efficiency of logistics system functioning. Simulating of each urban parameter, with unchangeable value of others, allows to evaluate its degree on invest performances of logistics system. The structural-logical scheme of research was design for achieved the goal, app. A.

On first stage the scientific and practical approaches for urban logistics services were analyzed; then city's parameters influencing on logistics servicing were identified and described in models; limitations to these models and techniques have been defined hereinafter; considered the borders of logistics system at the stage of distribution and existing performance indicators of its functioning in the city. The logistics services model that includes urban conditions has been developed after. Contracts requirements for logistics services were also considered in model. Simulation of logistics system in four Ukrainian cities was conducted for several retail networks in each. Simulation becomes possible to determine the patterns of change of logistics system indicators depending on the parameters of the city.

2. Analysis methods of logistics functioning in the cities

Cycle of transportation process includes: preparing goods for transportation (Filina-Dawidowicz, Iwańkowicz & Rosochacki, 2015), vehicles preparing (Nikolin, 1990), loading of goods (Davidich, 2006), execution of shipping documents (Vorkut, 1986), moving with cargo (Ambroziak & Tkaczyk, 2015), unloading and delivery of the goods (Kush & Skripin, 2016). Multiple repetition of the individual cycles affects the composition time of the linear transport (Xie & Levinson, 2011;). Average turnover time of vehicles is determined by Vorkut (1986):

$$\overline{T}_r^v = \frac{\bar{l}_m \cdot n_н^t}{V_t^v} + t_{li} + t_{uli}\,, \qquad (1)$$

where:

$\bar{l}_m$ - the average route length in km;

V_t^v - technical speed of vehicle, km/h; t_{li} - down time under load, h;

t_{uli} - idle time during unloading to service retailers, h.

$n_н^t$; $n_н^t$ - required turns number for the period t, units.

Time of movement depends on the technical speed (V_t), which value is usually set from previous traffic and load capacity of the vehicle, the time of day. As different data is in the range of 18 to 36 km/h

(Lobanov, 1990; Kush & Skripin, 2016; Lobashov, 2010). Some sources (Olhova, 2009) indicate that this values affect the parameters of a particular city, the road network density and automobilization level. Too high density network has drawbacks, such as capital investment in its construction, high operating costs for its maintenance, as well as the low speed of traffic as a result of frequent crossings (Efremov, 1980). Too low density hampers movement to a given point on the route. According to the current town planning regulations mean density of transport networks in the cities is in the range of 1.0 - 2.5 km / km^2 (Lobanov, 1990), while as a whole and its individual regions take different values, Table. 1.

An intersection, edge effects, stop at the edge of the roadway, the presence in the stream of vehicles of public passenger transport affect the characteristics of the movement and reduces the rate of flow (Efremov, 1980). On the performance indicators of the city also greatly affect (Kremenets, 2005): the delay time of vehicles, the length of queues in front of intersections, network bandwidth, traffic, density of road network, which is reduced with increasing the speed of movement and time combination. The speed of movement through the network, depending on the specific density can be calculated by the following relationship (Lobashov & Dulfan, 2013):

$$V = 17{,}4 \cdot Gn - 1{,}62 \cdot Gn^2 - 10{,}56, \tag{2}$$

where Gn - specific density of the road network in km / km^2.

Movement speed across the network, depending on the level of motorization for the city (Lobashov & Dulfan, 2013):

$$V = -1{,}29 \cdot 10^{-3} \cdot PA^2 + 0{,}326 \cdot PA - 1{,}66, \tag{3}$$

where PA - automobilization level, vehicle per 1000 people.

Sustained increase of automobilization level in recent years, with almost constant density of the road network affected the growth of traffic congestion, reduced traffic speeds in cities and major towns. Such situation leads to increasing of orders service time and costs of logistics providers (Yan & Dong, 2017). Simultaneously, its impact will be various due to the heterogeneity of the streets-road network in different parts of the town (Yu, 2017)

For modern Ukrainian cities the average level of automobilization is about 170-180 cars per 1000 inhabitants (Lobashov, 2010). This level is been limit for them and caused not only by the traffic capacity of the urban area, but also the difficulties of car use: the complexity of finding parking places (Verroios, Efstathiou & Delis, 2011); high capacity of streets (Cremer & Schoof, 1990); low-speed movement in the dense traffic flows (Steffen & Seyfried 2010) and others (Lobashov, 2010), and growing environmental protection problems (Dunlap & Scarce, 1991).

The average distance between the deliveries of the participants of the transport process, taking into account the parameters of the city can be described by the following parameters:

1. The nonlinearity factor of the road network (R);
2. Irregularity factor (δ);
3. The density of the placement of points of arrival in the territory of the transportation service (λ_∂).

To describe the irregularity distribution of points of arrival can be use the variance (δ) deviation from the average distance between points:

$$\delta = \frac{\sqrt{\sum_{i=1}^{n} \bar{l}^{\,air}}}{\sum_{i=1}^{n} l_{actual}^{airr}}, \tag{4}$$

where:

$\bar{l}^{\,air}$ - the average value of length between points "by air" km;

l_{actual}^{airr} - the actual value of length between points "by air", km.;

n - number of measurements, units.

The adaptation of the road network to the requirements of modern urban traffic estimated nonlinearity factor (Lobashov, 2010):

$$R = \frac{\sum_{i=1}^{n} l_{\partial op\_i}}{\sum_{i=1}^{n} l_{во з\partial\_i}}, \tag{5}$$

where $l_{\partial op\_i}$ - the distance between the participants of the transportation process on the road, km.

Value of nonlinearity factor (R) depends on the scheme of the road network (tabl. 2).

Table 1. Density street network backbone (Lobanov, 1990)

Groups of cities	The average density of main street network in the city, km / km^2	Including areas of cities		
		central	average	peripheral
The Largest	2,0-2,5	4,0	2,2	1,4
Large	1,8-2,1	3,4	1,6	1,2
Big	1,6-1,8	2,2	1,4	1,1
Medium	1,4-1,6	1,6	1,2	1,0
Small city	1,0-1,2	1,2	1,0	0,7

Table 2. Description of the town planning

Name of scheme	Description	Coefficient	Source
Free	The entire network consists of narrow crooked streets with variable width carriageway	-	Efremov, 1980; Cherepanov, 1970;
Radial	Complicated connections between peripheral regions, causing significant rerun and overload city center	>>1	Efremov, 1980; Cherepanov, 1970; Lobashov, 2010
Radial-ring	Has two fundamentally different types of highways - radial and ring	1,05 – 1,1	Efremov, 1980; Cherepanov, 1970; Lobashov, 2010
Triangular	There is no clearly defined central core and the possibility of even distribution of transportation throughout the city	1,4-1,5	Efremov, 1980; Cherepanov, 1970; Lobashov, 2010
rectangular	It includes chord and diagonal streets, punched in the existing building on the busiest destinations	1,2-1,3	Efremov, 1980; Cherepanov, 1970; Lobashov, 2010
hexagonal	The basis of the scheme is a combination of hexagons, excluded the formation of complex assemblies crossings on highways	-	Efremov, 1980; Cherepanov, 1970;

Density deployment of retailers $\lambda_д$, calculate as (Nefedov, 2007):

$$\lambda_д = \frac{N_{pc}}{S_м}, \qquad (6)$$

where $S_м$ – district service area (city square), km^2.

Considering the models, the mean distance between the points can be calculated from *R*, δ, λ according to the following formula:

$$\bar{l}_{cп} = \frac{\sqrt{\lambda_д^{-1}}}{R} \cdot \delta, \qquad (7)$$

System analysis of the logistics system is based on selection of the main elements of the structure and functions of the managing system. It is necessary to set links between its elements and evaluate efficiency of their interaction in system. Therefore, it needs to create a model, which describes logistics chain functioning including city's parameters.

3. Modelling of logistics services of retailers

3.1. Design logistics systems

Logistics systems characterized by large number of parameters (technical, technological, economic) and diverse links between them (Govindan, Kaliyan, Kannan & Haq, 2014). Therefore, it's necessary to define factors that directly affect the resulting indicators that researched. The parameters which consider mutual links between city's options and logistics system have been selected for proposed model. The peculiarity of the examined parameters is the universality of their application to different cities and logistics systems, as well at the same time the possibility of an individual tuned or adjusted according to the specific conditions of the urban environment or logistics systems. The basis for the resulting indicators calculation is the identifying of logistics service technology (Matthews, 2015).
For research logistics system it should be designed first, identify it borders, describe material flow, participants and their links. The logistic chain and consumer's goods are considered on distribution stage. System's participants are incoming flow,

transport participant and retailer network (RN). Transportation services are made by motor vehicles. Incoming flow provides a basic value of material flow parameters, fig. 2. Expenses on the incoming material flow stage will not be considered because it consists of a large number of suppliers, so considering the cost of each of it is rather complicated and unnecessary measures.

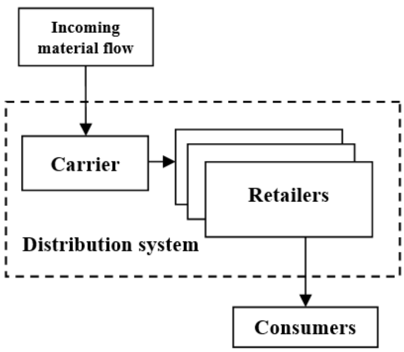

Fig. 2. Logistic chain scheme

Among the possible options for the organization of wholesale trader selected next: the company under the contract long-term lease takes in operation room equipped with all necessary communications, with the right to sublease space, not engaged in their own economic process. Retailers create a number of independent market actors. The effectiveness of the logistics system on distribution stage is estimating as a sum of the transport participant and retail network efficiency model:

$$NPV_{LS} = NPV_{Car} + NPV_{RN} \to \max , \quad (8)$$

where:

NPV_{Car} - net present value of transport participant, USD;

NPV_{RN} - net present value of retail network, USD;

NPV_{LS} - net present value chosen project, USD.

In the model is not planned to examine in detail the formation of revenues of the project, and explore possible revenue from paying fines for poor, ill-timed execution of their duties other participants in the system. The revenue of the project is defined as income from participants operations, depends on amount of material flows in logistics system.

Expenditure for each participant will have their characteristic differences, but all projects can be determined following structure of total costs (Vorkut, 2002): 1) capital investment for the project; 2) operation costs of organizing production; 3) costs for borrowed capital; 4) taxes and penalties for the project. As a result, the choice of various options of functioning logistics system (vehicle capacity and their number, the use of warehouse and cargo, the number of participants, etc.) are possible alternatives to the project, which provide different efficiencies. The effectiveness of the logistics system functioning of each individual option can access by the net present value of the project. The project of logistics system, with maximum indicator is best variant:

$$\mathrm{NPV}_{LS} = \max\left[\mathrm{NPV}_1', \mathrm{NPV}_2', ..., \mathrm{NPV}_g'\right], \quad (9)$$

where $NPV_1', NPV_2', ..., NPV_g'$, – net present value of alternative projects, USD.

The specific cash flows of different contracts of material flows distribution have variable values. This is caused by technological and economic characteristics of the logistics system of participants, development of engineering and technology, the stability of the financial situation of the participants of logistical system, the implementation of the budget, as well as external factors (discount rate, tax rate and the amount, legislation, competition, etc.).

3.2. Design of transport participant functioning and technology of transportation

Economic calculations are basing on technological indicators. Defining conditions and set technology in current cities allows calculating costs and revenues on this technology. The project's negative cash flow components for transport participant are shown in tab. 3.

The negative cash flow in *t* period can be calculated by formula (Roslavtsev, 2010):

$$C_t = K_t + O_t + P_t + H_t , \quad (10)$$

where:

K_t - capital investment in period *t*, UAH;

O_t - projects operating costs in period *t*, UAH;

P_t - the loan cost in period *t*, UAH;

H_t - tax expense in period *t*, UAH.

Table 3. The negative cash flow components for transport participant

Operating costs	Taxes
- The wages cost; - The vehicles maintenance and repair cost; - The fuel cost; - Depreciation; - General running costs; - The vehicles hiring cost.	- Income tax; - VAT; - Environmental fees; - Recycling collection.
Capital expenditures (K_t)	**Expenses on borrowed capital**
- Cargos and the vehicle drivers insurance; - The banking cost operations for transferring money; - The vehicle registration cost, more.	- The loan cost; - The leasing costs.

The investments (IC_t) may include the purchase of technical equipment, software, training staff, payment for research and development services, consulting companies or companies that specialize in the information implementation and telecommunication systems. Current expenditure depends on the purpose, scope, and requirements specifications for the simulation results.

Capital investment for the project based on the purchase price vehicles and costs associated with registration. These costs are disposable and made before the operation of the project. Also apply a single bank fees for the loan, invested in the first stage of the project. Capital expenditures can be calculated by (Roslavcev, 2009):

$$K_t = \sum_{a=1}^{A} \left(\begin{array}{l} K_{const\_t} + Ц^A \cdot \dfrac{H_{пф}}{100} + \\ + \alpha_{ком} \cdot Ц^A + H_{утл\_t} \end{array} \right), \tag{11}$$

where:

- A - vehicle, units;
- K_{const_t} - constant component costs connected with vehicles' registration, UAH;
- $H_{пф}$ - costs for the use of banking operations, %;
- $\alpha_{ком}$ - coefficient of one-time fee for credit;
- $Ц^A$ - price of vehicle, UAH;
- $H_{утл\_t}$ - utilization fee UAH.

Operating costs in period t can be calculated as:

$$\begin{aligned} C'_{пом\_t} = & \sum_{a=1}^{A} (C^A_{з/п\_t} \cdot N^A_t \cdot \left(1 + \frac{CH}{100}\right) + \\ & + \sum_{a=1}^{A} ((\eta^A_в \cdot l^A_{заг\_t} \cdot \beta \cdot 10^{-2}) + \\ & + (\eta^A_{бв} \cdot (l^A_{заг\_t} - l^A_{заг\_t} \cdot \beta) \cdot 10^{-2})) \cdot Ц^A_п + \\ & + \sum_{a=1}^{A} (\frac{Ц^A_{ш\_i} \cdot n^A_{ш\_i} \cdot l^A_{заг\_t}}{l^A_{ш\_i}}) + \\ & + C^{NMFB}_{зг\_t} + + \sum_{a=1}^{A} (Z^A_{dr\_t} \cdot Ц^A) + \\ & + C^{страх\_вант}_t + C^{страх\_НВ}_t + C^{страх\_КАСКО}_t + \\ & + C_{к\_t} + C_{найм\_t} + C_{аморт\_t} \end{aligned} \tag{12}$$

where:

- $\eta^A_в$ - linear fuel consumption per 100 km with a load, lit/100 km;
- $\eta^A_{бв}$ - linear fuel consumption per 100 km without load, lit/100 km;
- $Ц^A_п$ - the price of one litter of fuel for vehicle, UAH/km;
- $Z^A_{dr\_t}$ - coefficient comprising the cost of repairs and spare parts forvehicle;
- N^A_t - number of drivers who work on a separate vehicle, units;
- $C^A_{з/п\_t}$ - vehicle's driver wages, UAH;
- CH - interest deductions of taxes on wages,%;
- $l^A_{ш\_i}$ - run a tire *i*-type to replace km;
- $Ц^A_{ш\_i}$ - the price of one bus *i*-type, UAH;
- $n^A_{ш\_i}$ - required amount without a spare tire *i*-th;
- $C_{зг\_t}$ - average general costs, UAH;
- $C^{страх\_вант}_t$ - insurance costs risks associated with the delivery in period *t*, UAH;
- $C^{страх\_НВ}_t$ - the cost of drivers' insurance against accidents in period *t*, UAH;
- $C^{страх\_КАСКО}_t$ - the cost of insurance "CASCO" in the time period *t*, UAH.;
- $C_{аморт\_t}$ - depreciation, UAH.

The main taxes are defined as:

$$H_t^n = ПП_t + H_{пдв\_t} + H_{екол\_t} , \quad (13)$$

where

$ПП_t$ - income tax in the period *t*, UAH;

$H_{пдв\_t}$ - deductions for VAT in period *t*, UAH;

$H_{екол\_t}$ - environmental fee in period *t*, UAH.

These taxes in full can be defined as:

$$H_t^n = \begin{cases} 0, П_{оп\_t} \le 0 \\ П_{оп\_t} \cdot H_n \cdot 10^{-2}, П_{опт} > 0 \end{cases} + \sum_{a=1}^{A} \begin{pmatrix} D_t' - C_{м\_t} - C_{п\_t} - \\ k_{зг\_t} \cdot C_{зг\_t} - \\ C_{найм\_t} - C_{dr\_t} - C_{ш\_t} \\ -C_{страх\_t} - P_{осн\_t}^A \end{pmatrix} \cdot H'_{пдв\_t} + H_{екол\_t} , \quad (14)$$

Payments on borrowed capital:

$$P_t = P_{body\_t} + P_{\%\_t} , \quad (15)$$

where:

P_{body_t} -the amount of the loan payments in the period, UAH;

$P_{\%\_t}$ - the amount of payments for the use of credit in the period, UAH.

The positive cash flow in *t* period for transportation enterprise can be found as:

$$D_t^{TP} = \sum_{a=1}^{A} (n_н^t \cdot l_{ег}^A \cdot T_{км}) + \sum_{a=1}^{A} \theta_i \cdot T_{год} + \sum_{a=1}^{A} Q_{kt}^{мп} \cdot T_{ton}^{MF} , \quad (16)$$

where:

$n_н^t$ - required turns number for the period *t*, units.;

θ_i - work hours on the *i*-th route, hours;

TSC_h - the transportation service cost per hour, euro/hour;

T_{ton}^{MF} - costs per shipping for one ton (parties), UAH/t.

3.3. Design of participant of retail network

The revenue of retail network per period can be determined by the formula:

$$D_t^{rn} = \Pr_{orgin}^{1tonn} \cdot (1 + \frac{\bar{\Delta}_{RN}}{100}) \cdot Q_{kt}^{мп} , \quad (17)$$

where:

$\Pr_{orgin}^{1\,tonn}$ - the weighted average origin selling price of one ton incoming flow, UAH.

$\bar{\Delta}_{RN}$ - the average retail margin, %.

The costs of retail network per period t are equal to:

$$C_t^{RM} = U_t^{RM} + H_t^{RM} , \quad (18)$$

where:

U_t^{RM} - the average current expenditure by retail network, UAH;

H_t^{RM} - the average fixed taxes and charges by retailers, UAH.

The value of the current cost retail network in period t is formed of the following components:

$$U_t^{RM} = U_{at}^{RM} + U_{st/s}^{RM} + U_{pt}^{RM} , \quad (19)$$

where:

U_{at}^{RM} - costs for rent, UAH;

$U_{st/s}^{RM}$ - costs for staff salaries, UAH;

U_{pt}^{RM} - the cost for maintenance and repair of equipment, UAH.

The main retail network's taxes are determined according to the terms of his work (Roslavtsev, 2006):

$$H_t^{RN} = \frac{D_t^{RN} \cdot H_n}{100} , \quad (20)$$

where H_n– single tax rate, %.

The value of net cash flow for the period retail network determined as follows:

$$NCF_t^{RN} = D_t^{RN} - C_t^{RN} . \quad (21)$$

4. Results

4.1. The range of data model variation and limitation

City parameters and logistics system that examined in this paper have their variation range. Data variation is given in Appendix B. Investment costs in this analysis are the investment in the project for each participant. The discount rate conventionally accepted at 22 percent. Total functioning period depends on many factors and it's estimated for each project individually, within this work take it equal to 3 years.

Given parameters indicate real condition of Ukrainian economic. Suggested method can be used for other different cities, if they parameters are included in the range of data variation. Also results of obtained patterns can be valid for them too. In other way they have to be recalculated.

At the time of the turnover on the route affects its length. In its calculations, is used as a specific (certain) routes so (Nayan, & Wang, 2017) and average (Vorkut, 1986). The routes with the condition (22) have been used:

$$Q \geq q_н \cdot \gamma, \quad (22)$$

where:

Q - the volume of cargo carried per order, t;

$q_н$ - vehicle's load capacity, t;

γ - the capacity utilization factor.

The use of abstract route allows you to use the average distance between the delivery points of delivery, removal, which can be determined by the formula:

$$\bar{l}_м = \bar{l}_{cn} \cdot N_{pc}, \quad (23)$$

where:

N_{pc} -the number of participants in the retail network, units;

$\bar{l}_{cn}$ -the average distance between all participants of the transport process, km.

The calculation of the average distance between the participants of the transport process:

$$\bar{l}_{cn} = \frac{\sum_{1}^{n} l_{ij}}{n}, \quad (24)$$

where:

l_{ij} - the distance between the participants of the transport process, km;

n - the number of links between points, units.

In this formulation, all the items will be evenly spaced from each other, which corresponds to the ideal conditions of the problem.

4.2. Calculation of city parameters influence on transportation service

On the next stage of the study to estimate the average distance between the participants of the transport process was to identify the effect of the parameters of the city on real objects, 4 retailers were selected for this in Kharkiv: "ATB", "Kulinich", ProStor, "Foxtrot". Their shops were marked on the map and identify the shortest distance between them (Fig. 3, 4). The distance was determined using the service "Google Maps".

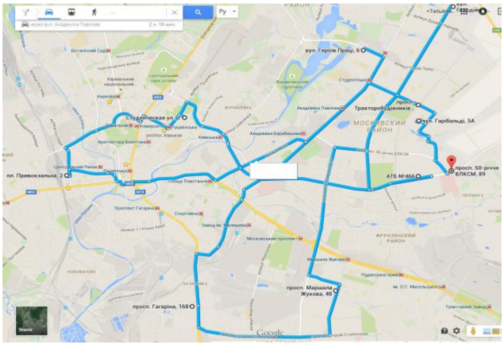

Fig. 3. Scheme of participants location c. Kharkiv (retail chain ATB)

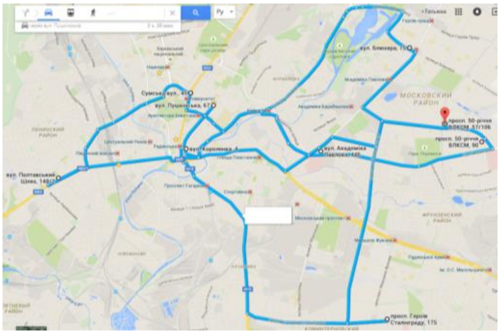

Fig. 4. Scheme of participants location c. Kharkiv (retail chain Prostore)

To calculate the participants of one retail chain misalignment coefficient of the road network in Kharkiv were marked on the map, measured the distance from the city center up to them "in the air" and "on the road" (Fig. 5, 6). The results of calculations of the road network misalignment factor are given in Table. 4.

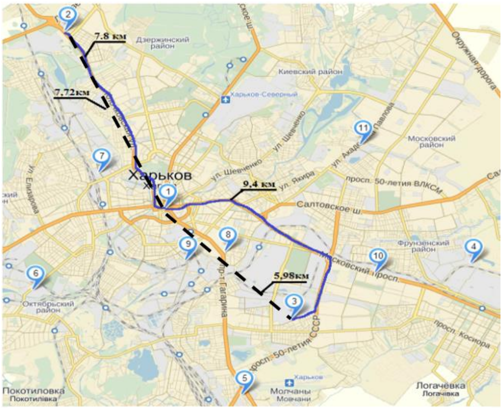

Fig. 5. Scheme of the participants of retail network "ATB" of road nonlinearity factor for Kharkiv

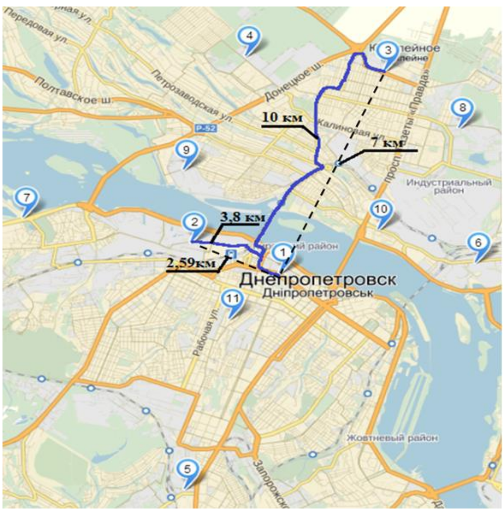

Fig. 6. Scheme of points for the calculation of road nonlinearity factor for Dnipropetrovsk

Table 4. Results of calculating distances in the network "ATB" for Kharkiv

№	Address	Distance by roads, km	Distance by air, km
1	vul. Geroyiv Pratsi, 6	-	-
2	prosp. Gagarina, 168	11	13
3	prosp. Marshala Zhukova, 4b	6	4,5
4	prosp. Traktorobudivnikiv, 107	9	7,7
5	pl. Privokzalna, 2	12,2	11,5
6	vul. Studentska, 7	5,5	4,3
7	SaltIvske shose, 143	9,8	7,5
8	vul. Gvardiytsiv-Shironintsiv, 102	8	5,9
9	vul. GarIbaldI, 5A	5,3	3,7
10	prosp. 50-richchya VLKSM,89	2,6	1,9
Total		69,4	60
Average		6,94	6,0

Distances from center to all retailers have been calculated by roads and "over the air" in all cities. Calculations of road's nonlinearity factor for 4 cities are summarized in the Table 5.

According to Table 5 there is no significantly different on nonlinearity factor within the one city, it's in scope 1.15 – 1.26. It should be noted that different values of the factor *R* indicate the different density of the road network in different areas. All considered streets networks in modern cities are unable to be in pure form. According from Table 2 and 5 results of nonlinearity factor of urban road network can identify each city planning scheme. Thus, for c. Kharkiv and c. Kyiv with a rectangular-diagonal scheme planning, and c. Lviv and c. Dnepropetrovsk – rectangular. Visual analysis confirms obtained results.

At the next stage with the use of eq. 7, have been calculating irregularity factor of placement of the participants of the transport network. Studies have shown (Table. 6) with an increase of maintains area and fixed retail's number of participants the average distance between the parties is increasing.

In case when the participants of the transportation process is evenly distribute from each other the irregularity factor will be 1 ($\delta = 1$); longer than the actual distance between points deviates from the average, the larger value will deviate from one. Irregularity factor (dispersion), which describes the deviation from the average distance between all participants. The calculation results are summarized in the Table 7.

Table 5. Results of nonlinearity factor of urban road network calculations for different cities

Name of the City	Number s / n	Name of RN	Nonlinearity factor	The average value of nonlinearity factor	Number of participants RN
Kharkiv	1	Household goods 1	1,23	1,2	10
	2	ATB	1,15		10
	3	ProStor	1,15		10
	4	Foxtrot	1,26		7
Kyiv	1	Household goods 2	1,44	1,3	10
	2	ATB	1,29		10
	3	ProStor	1,28		8
	4	Foxtrot	1,36		9
Dnipropetrovsk	1	Household goods 3	1,63	1,5	10
	2	ATB	1,55		10
	3	ProStor	1,48		10
	4	Foxtrot	1,47		5
Lviv	1	Household goods 4	1,38	1,4	10

Table 6. Results of irregularity factor estimation

Name of the City	Name of RN	Irregularity factor	The average value of irregularity factor	Number of participants RN
Kharkiv	Household goods 1	0,46	0,5	10
	ATB	0,51		10
	ProStor	0,48		10
	Foxtrot	0,56		7
Kyiv	Household goods 2	0,56	0,69	10
	ATB	0,79		10
	ProStor	0,72		8
	Foxtrot	0,69		9
Dnipropetrovsk	Household goods 3	0,41	0,34	10
	ATB	0,29		10
	ProStor	0,32		10
	Foxtrot	0,35		5
Lviv	household goods 4	0,8	0,85	10
	household goods 5	0,89		10

Table 7. Finding and results of speed calculations for different cities

City's Name	Indicators				
	Dispersion, %	The density of retail network, units/km^2	The average distance, km	The level of Automobilization, vehicles/1000 people	Specific density of the transport network, km^2/km^2 10^2
Kharkiv	50,25	0,042	2,01	143	1,97
Kyiv	69	0,017	3,97	200	1,5
Dnipropetrovsk	34	0,037	1,17	171	2,1
Lviv	85	0,078	2,16	187	1,8

According to Table 1 and Table 6 was defined quality characteristic for each city transportation network: for Kharkiv, Dnipropetrovsk and Lviv is small, for Kyiv is very small. Average travel speed network estimation according to specific density for cities and Automobilization level is presented in fig. 7.

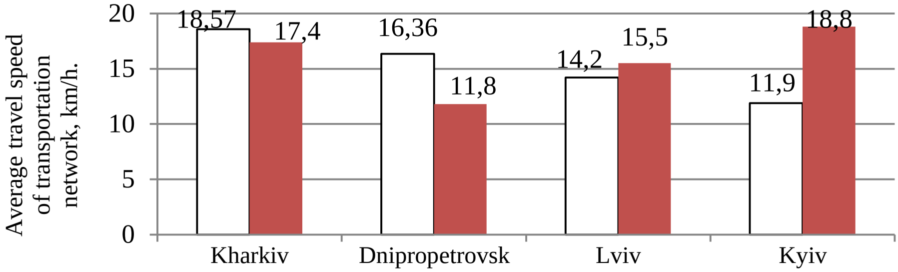

Fig. 7. Average travel speed of transportation network depending on automobilization level and density of road network:
- Vehicle’s speed by automobilization level estimation (Eq. 1), km/h;
- Vehicle’s speed by density of road network estimation (Eq. 2), km/h

4.3. Access influence of city parameters on efficiency of logistics systems

Collecting all the cities’ factors and efficiency results from proposed models (Appendix C) give opportunity to built characteristic graph (Fig. 8). Characteristic graph shows influence of one factor on final indicator with other non-changeable values. Overall impact of every city parameter according to proposed model allows finding regularities of logistics efficiency:

1) Increase value of parameters: density of streets and roads network, factor of irregularity leads to investment indicators increase.
2) Conversely, increasing the deviation from the average distance between points on the route of arrival, town square and automobilization level leads to decrease of NPV.

Thus, we can say that with the same technology for the implementation of transport services, the city's parameters have a different effect on the final efficiency.

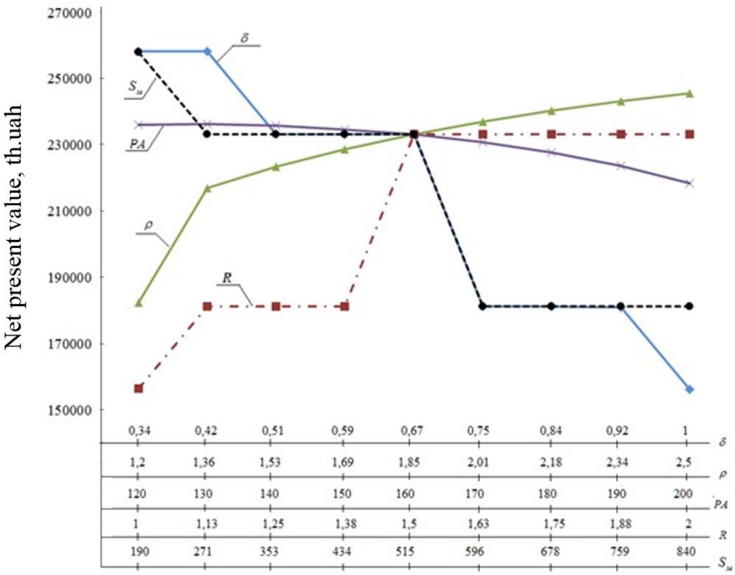

Fig. 8. Investment performance of logistics system functioning dependence on different cities parameters: δ – irregularity factor; ρ – density of retailers location; PA – automobilization level; R – nonlinearity factor; S_m – city area.

4.4. Practical suggestion on logistics system functioning

Based on proposed models NPV dependence from consumption volume and retailer's number (Fig. 9) and vehicle capacity (Fig. 10) have been calculated.

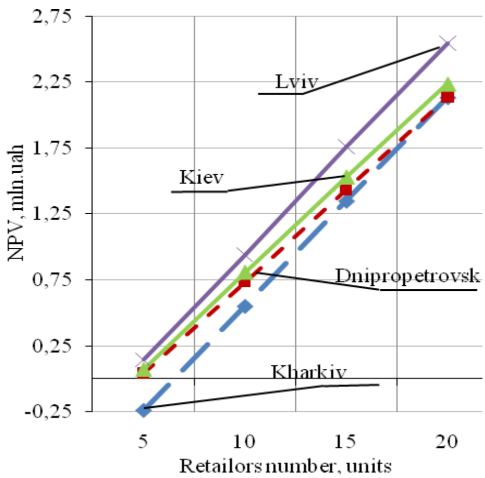

Fig. 9. Relationship between NPV on retailers number

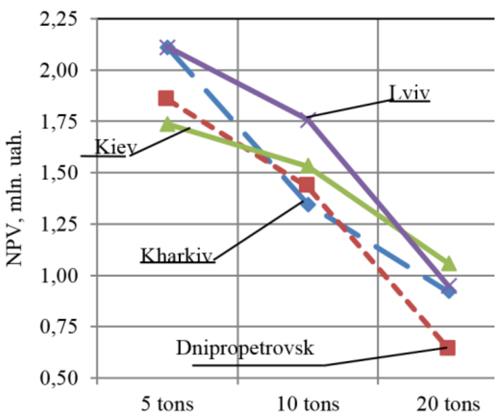

Fig. 10. Relationship between NPV on vehicle capacity using for distribution

Analysis of fig. 9 show that changes dynamics can be described by a linear function. Rise of retailers' number increase NPV. Kharkiv has the slowest rise and Lviv the highest. Fig. 10 analysis shows that NPV changes dynamics from the vehicle's capacity can be described by a nonlinear function. Modeling results shows that increase value of vehicle's capacity in urban distribution decrees NPV, due to diminishing efficiency of vehicle's use.

Basing on Comi, et al. (2008) one of the incentive-aimed differentiation is vehicle's size differentiation aims at creating incentives to use smaller vehicles in distribution stage. Although this form of differentiation is possibly lead to more trips performed by smaller vehicles (higher load factor, less time service per order, ect) reaffirms obtained results.

5. Conclusions

All factors of logistics environment can be divided into controlled, poorly controlled and uncontrolled. Controlled organization (enterprise) factors require effective planning and use of the organization. Poorly controlled – explore means of influence. Uncontrolled require adaptation logistics system to adverse conditions and use conditions favorable for the organization - to include such is the influence of the urban environment.

Analysis of factors of the transport process planning in the urban environment is still poorly researched in science and practice. Based on system analysis of logistics service and urban environment in first found regularities of city influence on efficiency functioning. Finding the parameters within certain limits allows you to make a profit for the logistics systems.

The analysis showed that there are separate approaches to the management of logistics, which indicate the rational advancement of the material flow movement and transport planning approaches, which characterize the city and solve the problem of managing traffic flows in it. Together, the issues of transport services and urban component impact (city parameters) have not been considered previously.

At the same time, the model has a number of limitations in use. This is primarily due to the range of data variation. The model has been modeling in the largest cities of Ukraine, where transport problems are particularly acute, but at the same time this model was not considered for other categories of cities. The influence of the urban environment will be different, due to different levels of automobilization, street network schemes, traffic management, etc. or in different cities and countries. But at the same time, general patterns are well traced and give understanding of urban environment component influence on distribution part of logistics system.

The proposed model makes it possible to assess the efficiency of the logistics system at the design and distribution stage for any logistics system in any city with certain improvements. Although the used models for calculation are applicable to Ukraine, especially in the tax and credit part of the costs calculations. Simultaneously, the proposed model with modifications to the environment can be applied to other countries. Also, in paper considered the use of own transport for servicing the retailers, the outsourcing option had not considered at all. In addition, incentive-targeted differentiation for using low consumption vehicles and advantages for society according to its use required further researched. Moreover, the transport policy regarding to freight transport for each specific city impose an impact on the results (Quak, & De Koster, 2006). For example, time-window regulations is use in Kiev.

The management of the distribution system for each individual urban service stands on different aspects of functioning: logistical, economic, marketing and solved at all levels of management. Proposed approach can be used to study any logistics chain and city's impact on it. Results give opportunity making managing transportation process for a particular retail chain given the city option more accurately. Also, it can be used in the design of logistics systems in different cities, areas, regions which fall in measure variation data also.

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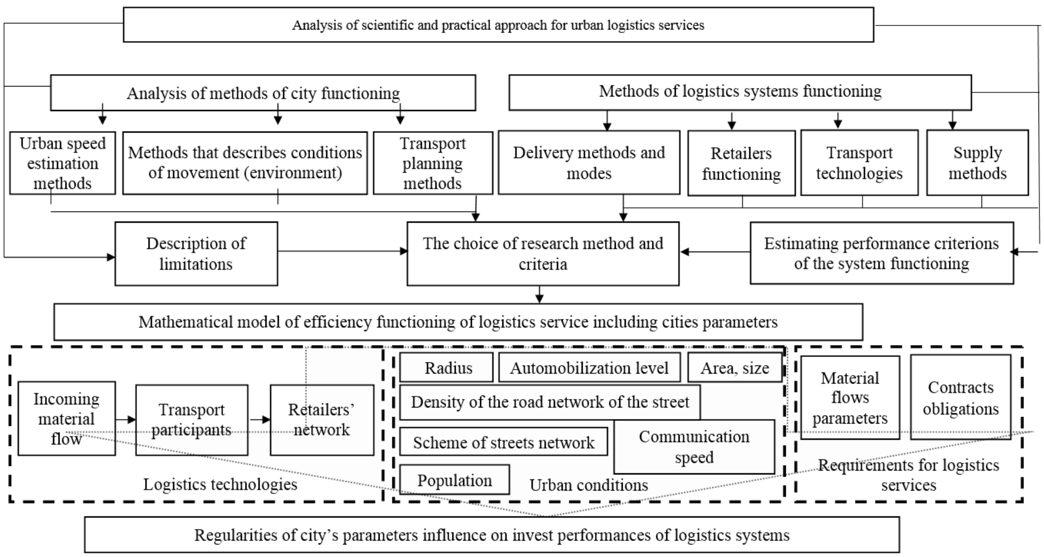
Appendix A. Structural-logical scheme of research



Appendix B. A range of varying of mathematical models' factors

№	Title of Models' factor	unit of measu-rement	The numerical value factor		Range changes	The base value factor
			Min	Max		
1	*2*	*3*	*4*	*5*	*6*	*7*
Requirement of the logistics system to transport services						
1	The average distance of transportation for the period MP	km	300	1000	–	500
2	Deliveries' volumes for the specified period	ton	3800	432	–	2200
3	Total number of material flow	units	1	3	–	3
4	Total number of clients (contacts)	units	1	3	–	3
5	The time period specified in traffic performance for the period	days	31	27	–	30
6	The cost of transportation services for the carriage of material flow	UAH/km	6	9	–	7,5
7	Load time, including waiting time	h.	–	–	–	3

8	Time of discharge, including waiting time	h.	–	–	–	3
Characteristics of the vehicle's parameters						
1	*2*	*3*	*4*	*5*	*6*	*7*
9	Load of vehicle	ton	10,0	25,0	–	20,00
10	The price of one liter of fuel	UAH/l	–	–	–	6,50
11	Vehicle's price, including delivery	UAH	400000,00	1000000,00	–	650 000,00
12	Required amount of oil	litter	–	–	–	35,00
13	Average path to replacing oil	km	–	–	–	50 000,00
14	The price of one liter of oil	UAH/ litter	–	–	–	80,00
15	The required number of wheels	units	–	–	–	12
16	The average price of one wheel	UAH	–	–	–	4 000,00
17	Average path to replacing one wheel	km	–	–	–	300 000,00
18	Factor comprising the cost of repairs and spare parts for Vehicle	%	–	–	–	15
19	Average of fuel consumption per 100 kilometers without cargo	litter	15,00	35,00	–	28,00
20	Average of fuel consumption per 100 km with a cargo	litter	19,00	40,00	–	33,00
21	Excess consumption to average in winter period	%	–	–	–	15
Characteristic parameters drivers						
22	Time for daily rest and hygiene of the driver	h.	–	–	–	10
23	Average time for Meals Breaks	h.	–	–	–	3,0
24	Average Time for daily maintenance and repairs of Vehicle during day	h.	–	–	–	1,0
25	Limitations of vehicle's driving	h.	–	–	–	8,00
Characteristics of transport services technology						
26	Carrying capacity utilization coefficient	–	0,4	1,0	0,2	0,95
27	The nominal capacity of the vehicle	ton	15	25	5	20
28	utilization factor of path	–	0,5	1,0	0,25	0,75
29	The average technical speed	km/h.	30	65	–	55
30	Number of drivers	persons	44	10	–	30
31	The lap's time	h.	48	72	–	58
32	The number of days in work	days	30	0	–	24
Characteristics of parameters of the economic system of the state						
33	The value of income tax	%	–	–	–	25
34	The value of VAT	%	–	–	–	20
35	Size utilization fee	UAH	–	–	–	25 000
36	Factor comprising the collection of environmental value	–	–	–	–	0,05
37	Average on salaries deductions	–	–	–	–	0,37
38	Permanent component costs associated with registration and registration of vehicles	UAH	–	–	–	2 000,00
Characteristics of carrier's parameters						
39	Factor comprising the share of wealth and collaborating institutions in the amount of overheads	–	–	–	–	0,1
40	Factor comprising contributions to the general running costs	–	–	–	–	0,03
41	Percentage deductions for amortization	%	–	–	–	40
42	Administrative and managerial staff wages	UAH	–	–	–	2 000,0
43	Number of Administrative and managerial staff	Persons	–	–	–	5
44	Driver's wages	UAH/ m	–	–	–	2 600,00
45	The number of drivers	person	44	10	–	30
46	The value of travel	UAH/day	–	–	–	45,00
47	The annual interest rate on the loan	%	–	–	–	17,00
48	The annual discount rate	–	–	–	–	18,00
49	The percentage margin to the tariff for the use of hired vehicles	%	–	–	–	15
50	The percentage of expenses for banking operations	%	–	–	–	1,5
51	The basic insurance amount is optional risks associated with delivery carried with every vehicle	UAH	–	–	–	5 000,0
52	The annual rate of insurance premium of the insurer under the insurance of cargo	%	–	–	–	4
53	The maximum value of material flow transported by rotation	UAH	–	–	–	800 000
54	The sum insured of compulsory insurance of the driver	UAH	–	–	–	500,00
55	The annual rate of insurance premium under the insurance contract vehicle full "CASCO" insurance amount of compulsory insurance of the driver	%	–	–	–	10
56	The annual interest rate for credit funds	%	–	–	–	18,00
57	The costs associated with the reorganization of carrier and aimed at organizing service of direct material flows	UAH	–	–	–	10 000

Appendix C. The range of results variation

№	Parameters	Indicator	Value of indicator								
			1	2	3	4	5	6	7	8	9
1	Deviation from average distance between points on the route of arrival	δ	0,34	0,42	0,51	0,59	0,67	0,75	0,84	0,92	1
		NPV	258255,6	258201,0	233228,3	233173,7	233119,1	181269,7	181199,8	181137,6	156164,1
2	Density street and road network, km^2/km^2	ρ	1,2	1,36	1,53	1,69	1,85	2,01	2,18	2,34	2,5
		NPV	182474,7	216922,8	223532,2	228718,3	233119,1	236890,2	240336,3	243144,9	245601,3
3	Automobilization level / 1000 people.	PA	120	130	140	150	160	170	180	190	200
		NPV	236128,2	236199,9	235740,5	234729,3	233119,1	230831,1	227743,7	223676,0	218356,6
4	Irregularity coefficient	R	1	1,13	1,25	1,38	1,5	1,63	1,75	1,88	2
		NPV	156420,5	181331,9	181331,9	181331,9	233119,1	233119,1	233119,1	233119,1	233119,1
5	City area, km^2	$S_м$	190	271	353	434	515	596	678	759	840
		NPV	258030,4	233119,1	233119,1	233119,1	233119,1	181331,9	181331,9	181331,9	181331,9
7	The amount of the material flow, tons.	$Q_{МП}$	1	1,5	2	2,5	3	3,5	4	4,5	5
		NPV	-1419219,2	-964226,9	-544491,8	-106366,5	233119,1	622662,4	1050794,4	1469132,2	1894970,3
8	material flow cost, UAH.	$C_{МП}$	850	906	963	1019	1075	1131	1188	1244	1300
		NPV	-763713,9	-515613,2	-263082,2	-14981,5	233119,1	481219,8	733750,8	981851,4	1229952,1
9	Number of retailer network participants, units	$N_м^p$	5	7	9	11	13	15	17	19	21
		NPV	-1270085,2	-862255,37	-472158,50	-86709,81	233119,12	588927,59	919293,48	1290097,8	1670307,3