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ASSESSMENT OF THE URBAN FREIGHT REGULATIONS IMPACT ON THE TRANSPORTATION COST

Andrii Galkin
O. M. Beketov National University of Urban Economy in Kharkiv, Department of Transport Systems and Logistics, 17 Bazhanova str., 61001 Kharkiv, Ukraine, andriy.galkin@kname.edu.ua (corresponding author)
Oleksii Nazarov
Ukrainian State University of Railway Transport, Transport Hubs Department, Feuerbach sq. 7, 61001 Kharkiv, Ukraine, nazarovalexej65@gmail.com
Ganna Shapoval
Ukrainian State University of Railway Transport, Department of railway stations and junctions, Feuerbach sq. 7, 61001 Kharkiv, Ukraine, shapoval@kart.edu.ua
Valeriia Kolosok
Pryazovskyi State Technical University Mariupol, Department of Transport Management and Logistics, 7 Universitetska str, 87500 Mariupol, Ukraine, kolosok_v_m@pstu.edu
Yana Khodova
Pryazovskyi State Technical University Mariupol, Department of Transport Management and Logistics, 7 Universitetska str, 87500 Mariupol, Ukraine, Khodova_y_a@pstu.edu
Anatolii Kuznetsov
O. M. Beketov National University of Urban Economy in Kharkiv, Department of Electric Transport, 17 Bazhanova str., 61001 Kharkiv, Ukraine, kai@kname.edu.ua

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Abstract: The paper will investigate the impact of the vehicle carrying capacity to which the local tax is applied on forming the cost of delivery. The cost of 1 ton of freight under different tax scenarios is estimated in the paper: without tax 0, with fixed tax – 10% and with progressive tax from 0 to 75%. The greatest effect on reducing the vehicle's load capacity during urban deliveries showed a progressive tax. The developed regression model allows determining the cost of transportation of 1 ton of goods depending on the technological parameters of transport operations, the costs of the transport (logistics) operators to perform these operations, and local tax regulations for transport. The application of the model makes it possible to regulate the use of vehicles of a given capacity by the local administration. In contrast to the strict prohibition on the establishment of traffic signs, the use of a progressive tax by the local administration makes it possible to regulate traffic structure by economic methods. Exploring of influence local tax regulations on transportation will lead to the sustainability of the cities in order to provide GREEN technologies.

1 Introduction

Managing the development of logistics is a vital task for industries and transport focused on the sale of goods and for entire retails, and other related industries focused on the livability of the cities. Researchers agree that the local policy of transport services is a very important stage in freight flows distribution, as it affects the final cost of goods, transport and freight flows, transport time, etc., in the cities [1,2]. Analysis shows expenditures on transportation services on the distribution stage of finished products in the world have increased by 12% since the beginning of the COVID-19 pandemic and, on average, account for 10% of sales [3]. However, the authors note that distribution costs continue to rise [4]. At the same time, the influence of traffic flows on the comfort of movement in cities has increased [5]: the number of private cars has increased, especially commercial vehicles – like HLV. In order to reduce the impact of these factors, urban logistics tools are used. One of the main factors that can be managing the attractiveness of the last-mile option is the cost of shipment. Transport policy regulations usually have a direct impact on the cost factor. The complexity of such regulations is related to the variety of stakeholders who become members of urban freight and their numerous connections and the very object of pricing in supply chains. Such objects are the cost of transport or logistics services from one side and external costs of society for this type of service from the other side. Depending on the conditions of transport regulations, the cost structure of the transport operator and the method of pricing in the freight transportation market change, which determines the volume of services provided to them. Exploring the influence of city tax regulations on the price and amount of transport or logistics services becomes a high-value task for theory and practice to achieve well-known concepts of Smart and Livability cities. Such regulation leads to stimulating greener services to reduce transportation by high capacity vehicles and internal combustion engine utilisation and towards EV or ect., sustainable scenarios in cities. Local tax regulations for transportation can be one of the authorities' options to manage transport policy and achieve marked goals. The aim of this paper is to assess the urban freight regulations into Ukraine transport policy and establish their effects on the transportation cost for Green city solutions.

The research includes the next steps:

- Literature review
- Methodology of research;
- Development of the Urban freight rate model including local transport tax;
- Determination of the influence value of urban freight rate on delivery value;
- Discussion and Conclusions.

2 Literature review

2.1 Urban freight efficiency

The transport participant is a separate link in the movement of goods in space and time from the places of origin to its consumption. Promotion of any freight flow is carried out according to the certain technology of transportation inherent in the given goods. Modern technologies aim to reduce transportation costs [6], zero-emission [7], sustainable transport development [8], etc. At the same time, the existing goals do not aim to study the connection between transport process technology and consumption [9]. This interaction is due to the use of steady demand in urban freight. The change in cost affects the demand and supply of transport in urban freight. Solving the problems of managing the cost of transport services will ensure the sustainable development of the city freight operator and the sustainable development of the city's transport system, which requires the use of new methods and technologies for managing them.

Among the models that determine the efficiency of transport services, there are models related to the evaluation of transport services by customers [10] and the own assessment of transport service carriers [11]. Such models include a large number of parameters of customer service quality, in other words, the requirements of transport services consumers to their service. Determining the source information for the calculation of this model is a difficult step because it requires data on the work of the carrier, which may not be available. Modern methods and models help to facilitate the functioning of transport in logistics systems as well as in other industries [12-14]. The key role of transportation in logistics is explained not only by the greater share of transport costs in the total logistics costs but also by the fact that without transportation, the very existence of material flows is impossible.

Analysing the work of transport operators of shipping goods, it can be noted that one of the main conditions for ensuring the efficiency of these systems is to meet the demand at the lowest cost. To do this, optimal routes are organised, the necessary brands of vehicles in terms of carrying capacity are selected, transport work is coordinated with loading and unloading posts, etc. [15]. Each logistics system in the process of its operation depends on its costs [16]. Analysing the structure of logistics costs, we can identify ways to improve the efficiency of the logistics system, one of which is the optimisation of delivery costs depending on the load capacity of the vehicle used [17]: Light commercial vehicles (LCVs) with grouse vehicle weight (GVW) less than 3.5 ton; Intermediate Light commercial vehicle (ILCV) with GVW of 3.5 to 8 ton; Intermediate commercial vehicle (ICV) with GVW of 8 to 10 ton; Medium commercial vehicles (MCV) with GVW of 10 to 15 ton; Heavy commercial vehicle (HCV) with GVW of 16 ton and above etc. The paper will investigate the impact of the vehicle carrying capacity to which the local tax is applied on the formation of the cost of delivery.

2.2 Transport policy regulations

The transportation cost affects the final price of goods to end-consumers, as well as it is add-value. The cost of transportation is often fixed in the urban environment by different operators. Constant technology provides sustainability and resilience of urban freight. But, variations of technological parameters (for instant, vehicle capacity changes) support changes in costs and urban freight rates, respectively. As the theory and practice of research shows [18-20], variation in the carrying capacity of a vehicle in cities is not a very popular management solution in Europe last years. Authors leave it constant due to several reasons for this:

- no other options in the fleet of the logistics operator. As a rule, the fleet consists of the same brands and typical vehicles that work according to a given technology. It is important to note the ease of maintenance of one brand of vehicles for the transport operator [21,22]. The increase in brand variations and vehicle carrying capacity will increase their maintenance cost, which is not always rational from the point of view of the revenue generated.

- lack of complete information and experience in the use of vehicles of different carrying capacity. The problem is related to the difficulty of predicting the operational performance of vehicles. Technological changes usually affect not only transport but also other participants in the supply chain: shippers and consignees [23];

- strict restrictions on the weight of the vehicle used in cities. Prohibition of HLV entry into cities or it is separate areas, historical centres, etc., reduces the possibilities by varying the carrying capacity of vehicles. Additional restrictions are imposed by «time window» and «green vehicles» [24];

- lack of a second chance. Buying a vehicle comes with a cost and should be justified enough. An active business does not have sufficient funds for experiments and wrong decisions. Therefore, any changes will be considered from many angles for a durable solution [25].

Mostly in CIS countries, scientific schools for the development of delivery technology determine the optimal vehicle's capacity for each delivery scenario or logistics system functioning [26-29]. During vehicle selection, it is operation indicators, specification, speed and delivery times, level of goods storage, the convenience of transportation, regularity of service, the complexity of service and other quality characteristics, the spatial location of transport infrastructure, level of competition in the transport market and other factors should be taken into account. In this regard, there are some questions about determining the rational type of vehicle and delivery scenario [29]: traditional trucks with internal combustion engines, electric cars, trucks, «passing cars» (carsheering), «passing deliveries» (crowdshipping)), drones [30].

Transport operations in logistics systems have a number of parameters: turnaround time, route length, tour quntity, quntity of depots and recivers, the required quntity of vehicles, etc. [31]. Management of this indicators makes it possible to increase the efficiency of transport services and, as a consequence, the scheme of goods distribution [32]. Transport operator operations associated with its implementation costs due to certain parameters. In a coherent analysis of the chain, it is proved that the parameters of a single transport operator can have a significant impact on the end-prize of the goods.

Modeling and simulation techniques are widely used to handle many variations. They allow to transfer all the necessary properties of real objects to abstract systems. This approach ensures the integrity of the system and allows to explore all scenarios for a long-term decision.

3 Methodology

3.1 Model description, limitations, collecting the data

The task of urban logistics can be solved on the basis of establishing a rational load capacity, which provides a minimum cost of goods delivery. The establishment of local tax regulations for transportation capacity allows you to adjust costs (increase or decrease) depending on market conditions and the need to use vehicles of a certain capacity in the transport system of the city. It is possible to obtain such an effect by applying transport regulation in the formation of transport rates.

This approach leads to a set of interrelated functions, the implementation of which provides the desired effect in achieving the goal of functioning of the urban transport system and logistics operator as an integral system and not its individual components. These aspects cannot be considered in isolation but should be based on their interconnectedness, and the effectiveness of the decisions taken should be assessed in the light of the interests of all stakeholders involved in the delivery of the goods. To study urban freight regulations impact on the transportation cost it is necessary:

1. Set up the data source and system limitations.
2. Build a mathematical model of the transport services cost depending on the parameters of time and distance after taking into account local tax regulations for transportation capacity.
3. Establish the impact of changing the value of local tax regulations on the cost of delivery. Consider zero (tax-free), fixed, and progressive local tax regulations for transportation capacity.

To study the logistics chain functioning boundaries of the system, number of participants and their interaction was determined. The process of goods delivery on Kyiv, Kharkiv and Mariupol example was analysed. Due to numerous number of technologies the grocery food flow was applied for further analysis. The statisticla records from indystry was obtained and personal obsevations at logistics (transport) operators were made. The following delivery attributes that characterise retail networks and routes were selected for the study: time on the route when servicing the retail network; the distance travelled by the vehicle during maintenance. Such parameters are decisive for the formation of the transportation cost according to [22,27]. In addition, local tax regulations for transportation capacity and vehicle carrying capacity were established. The collected range of variation of these parameters is given in Table 1. The number of experiments was determined from the nomogram of sufficiently large numbers on the basis of the permissible error $\varepsilon = 0.05$. The Pearson's fitting criterion (χ^2) for confidence probability $P = 0.95$ and permissible error $\varepsilon = 0.05$. was estimated.

Table 1 Data variation range

Parameter	Units of measurement	Minimum value	Maximum value	Average value
Total time of transportation in retail network	hrs	1.55	23.00	6.00
Total distance of transportation in retail network	km	2	2250	25
Load capacity of the vehicle	t	2	22	10
Local tax regulations for transportation capacity	%	0	45	20

3.2 Model description, limitations, collecting the data

Analysis of the costs of the transport (logistics) operator indicates their dependence on the technological indicators of service time and total mileage on the routes. Also, the total cost of transporting goods consists of variable costs ($C_i^{TO\_зм}$) and fixed costs ($C_i^{TO\_пост}$):

$$C_i^D = C_i^{TO\_\text{пост}} \cdot T_i^{TO} + C_i^{TO\_\text{зм}} \cdot L_i^{TO} + T_i^{\%TO} \rightarrow min \quad (1)$$

where $C_i^{TO\_\text{пост}}$ – fixed transportation costs, UAH/hour; $C_i^{TO\_\text{зм}}$ – variable transportation costs, UAH/km; $T_i^{\%TO}$ – local tax regulations for transportation, %; L_i^{TO} – total distance of transportation in retail network, km; T_i^{TO} – total time of transportation in retail network, hours.

In addition to the costs of the transport (logistics) operator, local tax regulations for transportation have been added to the model as a component of the city logistics balance. Increasing the carrying capacity of vehicles reduces the delivery cost of 1 ton of goods [33]. The use of heavy-duty vehicles has a greater impact on the environment and other external costs than LCV or ILCV. The introduction of the tax will stimulate operators to operate vehicles with lower capacity and as a result will move towards a sustainable scenario of transport development in cities, Figure 1. 3 scenarios are considered: Scenario 0 – current situation, tax is not applied; Scenario A – tax is fixed at 10% for all types of vehicles, Scenario B – tax is progressive and consists of 0% for LCV, 10% for ILCV, 25% for ICV, 50% for MCV, 75% for HCV.

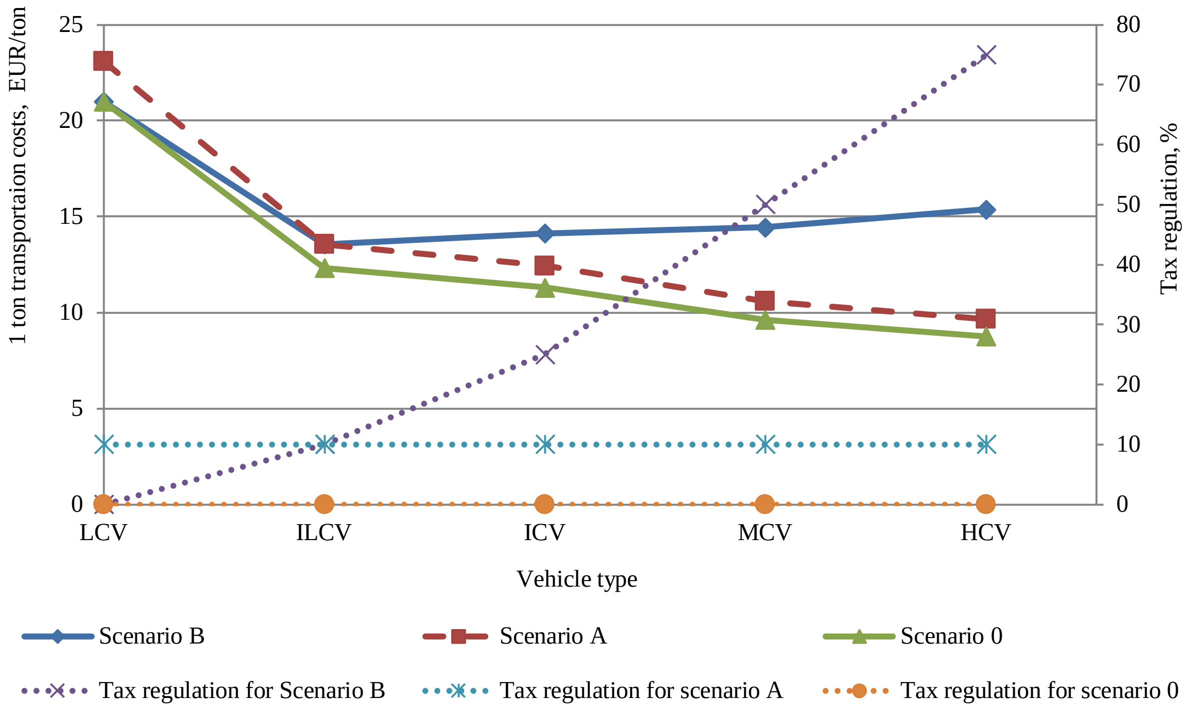

Figure 1 Scenario of a single ton transportation costs and tax regulation on type of vehicle, average demand of retailer is 1 ton

From the graphs (Figure 1) we see that the increase in the carrying capacity of vehicles leads to a change in the cost of transportation of 1 ton of goods. Transport costs and tax regulation are considered as a component of the goods delivery cost to members of the retail network. Such a change in indicators is interdependent. Initially, the increase in load capacity from LCV to ILCV affects the reduced cost of delivery, and with further growth there is a slight increase. The relationship between the indicators can be explained by the following circumstances. Increasing the load capacity of vehicles to a certain level helps to reduce the costs of the transport operator for a certain amount of restocking in system. Rational is such a capacity that minimises logistics costs per unit of delivery. With the considered parameters of the distribution scheme, it is advisable to use vehicles with a carrying capacity of ILCV, Figure 2 and Figure 3.

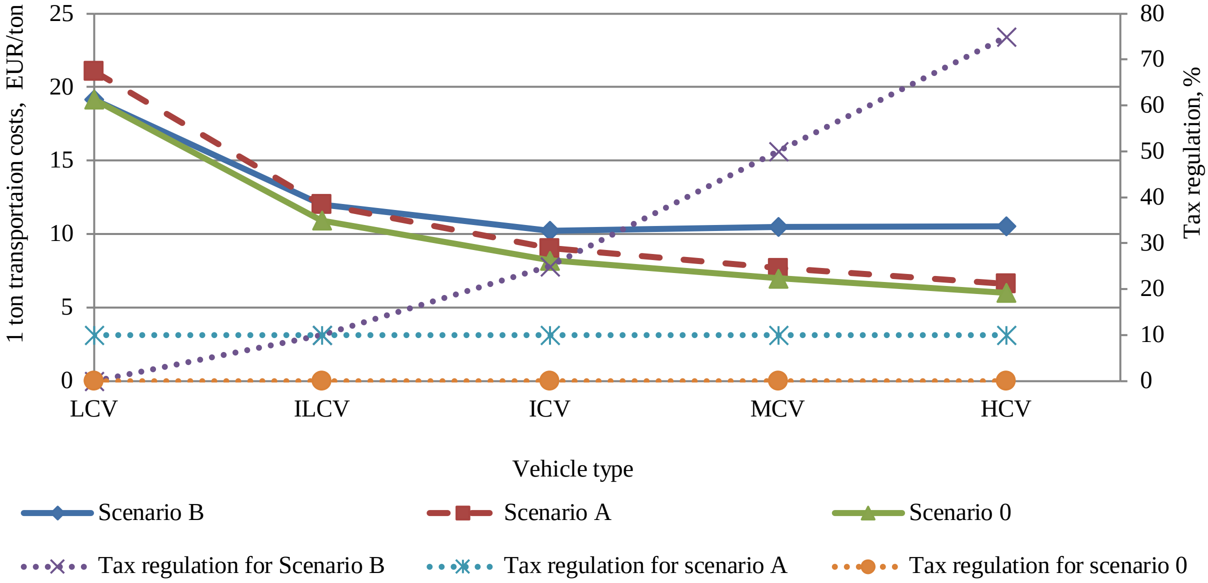

Figure 2 Scenario of a single ton transportation costs and tax regulation on type of vehicle, average demand of retailer is 3 ton

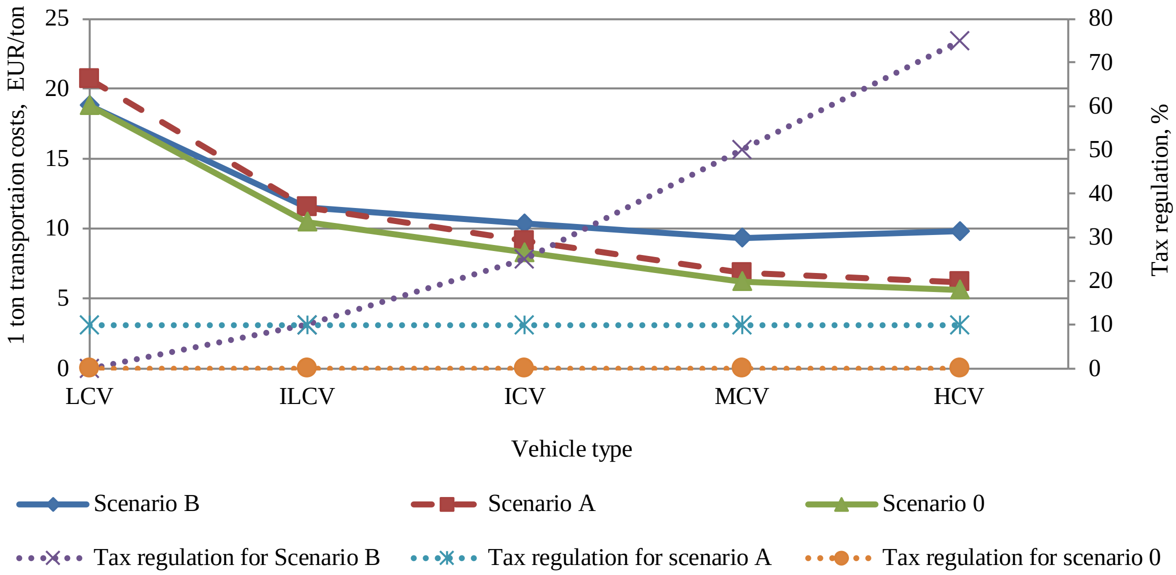

Figure 3 Scenario of a single ton transportation costs and tax regulation on type of vehicle, average demand of retailer is 5 ton

Analysis of Figure 1-3 showed that there is such a rational load capacity of the vehicle, which provides a minimum cost of delivery in accordance with local tax regulations. Increasing demand of delivery to 3 tons at Figure 2 and up to 5 tons causes an increase in the rational load capacity to ICV and MCV respectively.

Using the obtained data, the influence of each considered parameter on the cost of delivery was estimated. Using correlation-regression analysis, a model was obtained for the change in the average cost of one order fulfilment when servicing a retail network, taking into account local tax regulations for transportation capacity:

$$TSC_i^D = \frac{3{,}833 \cdot \sqrt{L_i^{TO}} + 0{,}28 \cdot (T_i^{TO})^{1{,}4} + 217{,}71 \cdot \left(\frac{T_i^{\%TO}}{100}\right)^2}{Q_i}. \quad (2)$$

The regression coefficients were calculated by the method of least squares. The results of model evaluation are given in Table 2, Table 3.

Table 2 Model evaluation results

Indicator	Value
Students' criterion:	
tabular	1.97
estimated for total mileage	2.20809
estimated for the total service time	2.00112
estimated for local tax regulations for transportation capacity	5.44039
Fisher's index:	
calculated	3.88
estimated	109.89
Correlation coefficient	0.9463
Determination coefficient	0.8956
Average approximation error	8.34

The results of statistical evaluation prove that the obtained model is characterised by a sufficiently high information capacity, as evidenced by the estimated value of Fisher's index 109.89, which exceeds the tabular 3.88. The estimated Students' criterion is equal to 2.208 for the total mileage, 2.00 for the total service time, 5.44 for the rate of return of the transport operator, tabular 1.97. The degree of correlation is 0.94. The average approximation error is 8.34%. Therefore, we can conclude that the obtained model adequately describes the dependence of the change in the average cost of one order when servicing the distribution network on the total mileage in the supply system, total service time, local tax regulations for transportation capacity.

Table 3 95.0 %-confidence intervals for estimating model coefficients

Parameter	Calculated coefficient	Standard error	Lower border	Upper border
Total mileage in the supply system	3.8329	1.73585	0.3741	7.2916
Total service time	0.2797	0.13980	0.0011	0.5583
Local tax regulations for transportation capacity	217.71	40.0174	137.97	297.44

Analysis of the model (2) of the delivery cost, taking into considering local tax regulations for transportation capacity showed that with increasing total mileage, total service time and the amount of tax increases the average cost of one order.

Obtained model can be used for estimating TSC for Ukrainian cities in order to facilitate reducing transport problems and provide necessary sustainable regulations. The results were obtained was disseminated on 3 cities which have different size, populations and other parameters. Obtained data define limitations of suggested method in order to data set was observed and collected statistics. The results allowed modeling the TSC for logistics (transport) operator for some adjustments in estimating the limits of business (taxation system), type of goods, distribution zone traffic regulations, green vehicle utilisation and other. This information can be initial data for further research and developing more specific model for each type of scenario.

4 Conclusions

The paper estimates the costs of 1 ton of freight under different tax scenarios: without tax 0, with fixed tax – 10% and with progressive tax from 0 to 75%. The greatest effect on reducing the carrying capacity of the vehicle during urban deliveries showed a progressive tax. The size of the tax can be changed depending on the conditions of application (city, population, level of motorisation, etc.). The current values of taxes applied in the work refer to large cities of Ukraine such as Kharkiv, Dnipro, Odessa, Kyiv, Lviv, Mariupol. The article simulates the volume of retailer demand in the delivery system. The increase in the volume of material flow in the logistics chain causes an increase in the rational carrying capacity of vehicles.

The proposed model allows to determine the cost of transportation of 1 ton of goods depending on the technological parameters of transport operations, the costs of the transport (logistics) operator to perform these operations, and local tax regulations for transport. This method takes into consideration the parameters of the participants in the process of transportation and demand, reflects the relationship between the parameters of supply systems and local government. Based on this, it can be argued that the cost optimisation of transport operator leads to increased efficiency of logistics which support the goal of paper to investigate the impact of vehicle carrying capacity to which the local tax is applied on the formation of the cost of delivery.

The application of the model makes it possible to regulate the use of vehicles of a given capacity by the local administration. In contrast to the strict ban on the establishment of traffic signs, the use of a progressive tax by the local administration makes it possible to regulate the structure of traffic by economic methods. The transport (logistics) operator decides to pay a high tax or change the delivery technology and not pay the local tax. Reducing the vehicle's load capacity leads to a decrease in the volume of delivery and an increase in the frequency of deliveries, which positively affects the size and value of inventories of retail participants – reducing it. The funds received by the local administration as a result of the application of such a tax can be used to ensure the sustainable development of transport infrastructure or to stimulate investment in green logistics, etc.

Effective logistics management occurs when an optimal balance is established between logistics costs and local tax regulation for the use of different types of transport. For the consumer, not only the final price of the product is important, but also the level of service, accessibility and convenience of movement, and care for the environment. The use of LCV, ILCV reduces emissions and congestion on the roads and contributes to the sustainable development of society.

Thus, we have focused on one basic principle of creating persistence of delivery in green cities. We conclude that an effective supply chain delivery scenario is not based on an «entirely new» skill set. Instead, efforts to create more sustainable practices contribute to continuous business improvement. The development and fine-tuning of urban logistics management is a largely continuous process of improvement based on past experience and new research.

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Review process
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