

Ecological and Economic Aspects of Innovative Development of Urban Logistics Infrastructure Taking Considering Pandemic Constraints

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Abstract

The relevance of the topic is determined by the existence of inconsistencies between economic and environmental aspects of innovative development of urban logistics infrastructure, as well as the conflict of public, state and private commercial interests in this issue. The purpose of the article is to determine the principles and effective tools for innovative development of urban logistics infrastructure, taking into account pandemic constraints. The influence of the environmental aspect on the dynamics of transport flows was analyzed in detail and characterized, the scheme of determining the optimal solution for the development of the city was proposed considering the compromise between economic and ecological interests of society, state and business entities. A scheme of innovative development of urban logistics infrastructure under pandemic constraints was also developed. Materials of the article are relevant for developers of city plans, managers of urban logistics infrastructure, employees of enterprises participating in transport and logistics markets, scientists, and doctoral students.

Key words:

ecology, innovative development, urban logistics infrastructure, sustainable development, pandemic constraints.

1. Introduction

The dynamic development of the world economy has led to diversification processes in production and consumption, and thus there is an increase in environmental pollution. This requires more detailed study into these issues. Researchers have substantiated the socio-ecological component of development using elements of cognitive modeling. The authors proved the existence of a direct causal link between the anthropogenic impact on the environment and human health, which necessitated

the development of technological safety parameters. Along with environmental safety, cultural development should be recognized as an integral part of the success of society's development. As noted by Bakhov et al. [1] it is the socio-cultural development of society that is able to provide a synergy effect activating economic activity.

A review analysis of previously published studies made it possible to establish that modern science, having a solid theoretical and methodological basis in the field of sustainable development, is in dynamics, therefore, there is a need to conduct a systematic analysis of the works of various authors in order to establish cause-and-effect relationships and form their own conclusions with a current orientation. So, in the article by D. Pataki [2] the author focuses on grand challenges of urban ecology at present. There is a rapid increase in urbanization in the world, as well as globalization of resource allocation and a significant expansion of the role of urban ecology in general. One should agree with the author's thesis that the scientific community faces such challenges that require a thorough study of urban ecology. At the same time, in our opinion, it is inextricably linked with the modelling of traffic flows, as the main factor of pollution in cities.

A group of authors [3-6] proposed ways to integrate studies on urban ecology and sustainable urban development. The authors insist on the need to develop new methods and tools for such integrated complex research. In particular, it is doubtless that there is a need to integrate urban environmental

studies with urban economics and urban planning. However, the research does not focus on the modelling of transport flows, without which, in our opinion, a comprehensive study of urban ecology is impossible.

Fundamental research S. Pickett et al. [7] is devoted to the expansion of urban environmental science paradigms. The authors highlighted the integration of urban ecology with general ecology and biology, as well as a system socio-ecological approach. As a result, a multidisciplinary paradigm is formed that provides for a dialogue between society, city authorities, specialists and researchers for the sustainable development of cities. In our opinion, the expansion of the paradigms of urban environmental science is impossible without management of cities' transport flows.

As noted by Galkin et al. [8] the period before COVID-19 was characterized by increased demand for quality trading services, which provided an increase in the customer base of retail networks. The authors experimentally evaluated the impact of the emotional component on the purchasing process using neuromarketing tools and found that this impact is different in various types of retail trade. It should be noted that at present these studies require updating and taking into account the impact of the spread of COVID-19 and related limitations, especially in customer interaction.

Virtual logistics management, which forms an environment based on the use of the logistics 4.0 approach and neuromarketing, is becoming the most promising area of development. The results of the study revealed a significant level of integration of all participants and the need to systematize their joint study based on the development of a single indicator for assessing the effectiveness of cooperation with a comprehensive consideration of participants' interests. Further dissemination of green logistics solutions contributes to the greening of cities. Within the study on development [8], scenario modeling was performed based on the algorithm for selecting the technological scheme of delivery. Not only economic effectiveness but also environmental factors were assessed. Although in accordance with the study results it was found that delivery using crowdshipping technology is 6 times more expensive, it has significantly reduced emissions. The authors emphasize the possibility of forming methods for assessing the use of the delivery scenario, and in our

opinion, this study is also valuable because it comprehensively assesses the environmental and economic component in the alternative choice. Finding a reasonable compromise between environmental and economic factors is, from our perspective, the cornerstone of the successful development of urban logistics infrastructure.

In the study [7], the authors conclude that the usual models of metropolitan and megapolitical urban structure, as well as industry-oriented urban development are inadequate. They emphasize the need to develop a comprehensive concept – the urban megaregion and the continuum of urban planning, which provide a common conceptual structure for the consideration of urban areas of different types and forms. It is necessary to agree with the authors in emphasizing need for further research in this area.

The complexity of the choice of socio-ecological indicators for assessing the sustainability of the coastal urban area is determined by the four-phase function of the target system and a three-sphere dimension. Moreover, three areas are defined as economy, ecology and natural resources (Liang and Li, 2020). The dynamic principle determines the effectiveness of evaluation results. The significance of the study is also defined by the implementation of the author's tools for the integration of land use, water management and preserving biodiversity in management through the means of ensuring stability and sustainability for the coastal zone. This study is relevant for Ukraine in terms of the development of urban logistics infrastructure in port cities.

The study of urban logistics infrastructure is impossible without a detailed study of urban mobile traffic. In the study, Chechina et al. [9] study macroscopic and microscopic approaches to mathematical modeling of multilane road traffic in cities. In the macroscopic model, the authors identified a variable of the transverse velocity, which reflects the rate of changing of the lane, while the microscopic model is based on the theory of cellular automata and investigates the multilane case. These studies are extremely important, both from theoretical and practical point of view, the use of their results will optimize the algorithms of traffic lights' operation in real time, give better understanding the possibilities of using lanes, including reverse traffic. Interesting is the work of W. Hundsdorfer and V. Savcenko [10], which considers local accuracy, propagation of interpolation errors

and stability based on numerical experiments, in particular using higher levels of specification with automatic distribution.

Management of cargo flows on the railway should be carried out on the basis of logistics supply chains by type of connection for each shipment [11]. The analysis of factors contributing to the imbalance of cargo flows in large-scale minor ports of Malaysia using a fuzzy analytical hierarchy process was done by M. K. Othman et al. [12]. The paper of J. A. Moscoso-López et al. [13] was devoted to predicting the future values of the Ro-Ro perishable cargo flow using a forecasting system. Researchers A. Banaszek and T. Urbanski [14] developed an algorithm and performed calculations for pumping some liquid cargoes with different viscosities and densities. Therefore, the insufficient level of studying ecological and economic aspects of innovative development of urban logistics infrastructure taking into account pandemic constraints becomes obvious.

2. Methodology

During the study process and system approaches, as well as various methods such as historical, terminological, comparative, statistical, deduction, expert assessments and market analysis were used. It should be noted that there is a dynamic growth in the number of private vehicles around the world, which leads to an increase in the total number of transport in cities and a deterioration in the overall ecology of cities. The lack of sufficient parking spaces also has a negative impact on the urban environment.

Car delays, unlike passengers, have a negative impact on the urban ecology as a whole. At the same time, it should be kept in mind that the urban ecology suffers primarily from emissions of CO and other toxic components and carcinogens into the atmosphere. In the meantime, the influence of other harmful factors from car traffic is secondary.

The availability of tools for effective control of vehicle emissions into the atmosphere is one of the main tactical techniques for a partial solution of the city's environmental problems. This issue becomes especially acute at crossroads, where the concentration of harmful substances can often exceed the average value in this urban area by 3-5 times. Reducing congestion on side streets is also a significant factor in improving the environmental

situation in cities. In addition, the uniformity of vehicle movement also contributes to a decrease in emissions from cars, since when cars stop and speed up frequently, emissions of harmful substances and carcinogens into the atmosphere increase many times over.

It should be noted that cars are a significant (sometimes the main), but not the only pollution factor in large cities. The load on the ecology of large cities can increase sufficiently, in particular, in conditions of large fire spots in and around the city. We observed a similar situation in Kyiv, the capital of Ukraine, in February-April 2020, when the air pollution index exceeded 150 points on some days, making it the most polluted city in the world. In general, delays in pedestrian movement en route, as have been already mentioned, do not directly affect the environment, at the same time inefficient distribution of time of the population is one of the key factors negatively affecting the use of resources of the country as a whole. Furthermore, within the framework of the problem to be solved, it is obvious that part of the pedestrians is transformed into passengers on private or public transport, and therefore will directly affect the congestion of the transport system of the city and as a consequence will have a negative impact on the urban ecology.

The creation of state programs for transition to ecological fuels should be recognized as a strategic task at the state level. Much effort has been made to switch to alternative fuels, in particular biofuels. In Ukraine, as well as in the EU, rapeseed is actively cultivated, which can be used to solve such problems. The majority of leading countries of the world actively use biodiesel in diesel fuel, as an additive. Often its share can be up to 40%. Definitely, the use of biofuel in some cases does not reduce, and sometimes increases, CO emissions into the atmosphere, as its production can cause additional sources of emissions, but in terms of urban ecology, the use of biofuels is a definite plus and leads to a reduction of emissions and improves the environmental situation in large cities.

Studies of the EU transport market presented in show that the highest distribution of alternative fuels for cars among these countries was observed in Poland (15.9% in 2018 as compared to 15.4% in 2017), Italy (8.6% in 2018 in comparison with 8.3% in 2017), Lithuania (8.6% in 2018 as compared to 9% in 2017). At the same time, in island countries such

as Cyprus and Malta, the use of alternative fuels in cars is reduced to almost zero. The wider use of environmentally friendly cars that meet modern requirements for air emissions is also becoming a strategic task at the state level. Analyzing the rate of automobile renewal, it should be noted that there is no trend for greater renewal of vehicles in more developed countries. Thus, as of 2017-2018, the largest number of new cars during this period was in Luxembourg, Lithuania, Belgium and Bulgaria, and the smallest – in Romania, Latvia, Finland and Estonia. As it can be seen, the most developed EU countries are present in both parts of the list, as new EU members are also represented among the countries with the highest fleet renewal rate for 2017-2018, as well as the lowest rate.

3. Research Results

As noted in urban population growth will reach almost 2.5 billion people by 2050, and the vast majority of this increase will be in Asia and Africa. It will result in a further negative impact on the urban ecology of these regions, which is still rather critical in particular areas.

This problem is primarily solved by the creation of the efficient urban public transport network, which should facilitate the redistribution of passenger traffic from personal to public transport. Among other ways to solve the problem, effective urban infrastructure planning using the latest technologies and solutions can be applied. Obviously, these mechanisms require a comprehensive city development plan and sufficient financial investments. Position of the environmental aspect factor influence on the dynamics of traffic flows is presented on Fig. 1.

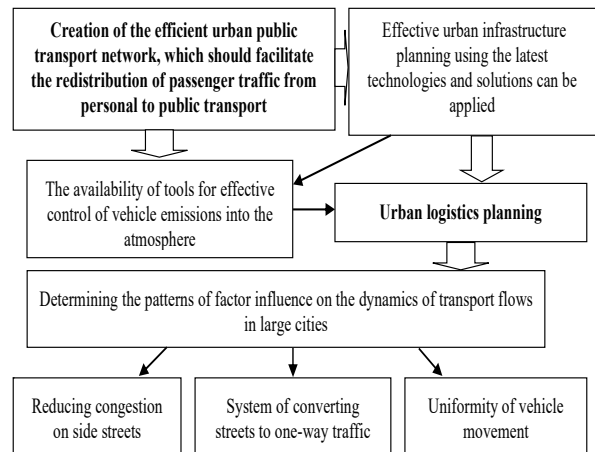


Fig. 1. Environmental aspect factor influence on the dynamics of traffic flows

Air quality in cities is one of the most important evaluation indicators of urban ecology. Thus, according to estimates the most polluted are the cities of India, China, Pakistan and Bangladesh. Herewith, it is important to mention about the average annual rate of urban air pollution, while the peak indicators can also be considered critical. Hotan (China), being in the top 50 cities by average annual pollution, had peak average monthly values (in March 2020) identified by experts as life-threatening.

However, the urban environmental level is determined not only through city air quality. Each city is gradually developing economically, which has a negative impact on the environment. So, there is a conflict between the economic and environmental interests of society, the state and business entities. Urban infrastructural development will depend on the effectiveness of its solution. The general scheme of determining the optimal solution for the urban development, taking into account the compromise between economic and environmental interests of society, the state and businesses is given in Fig. 2.

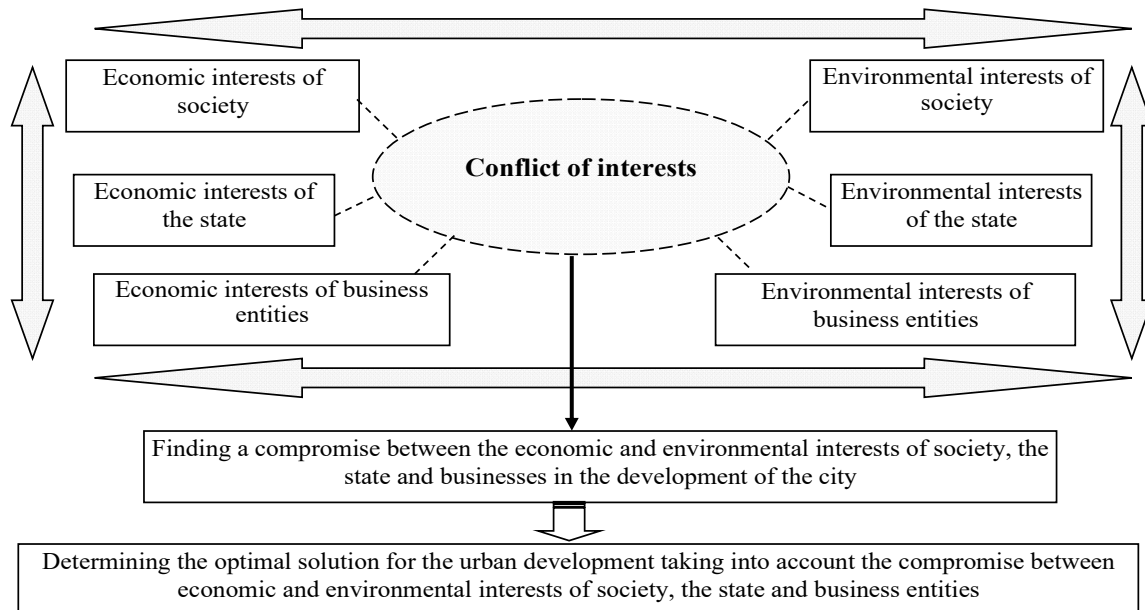


Fig. 2. The general scheme of determining the optimal solution for the urban development considering the compromise between economic and environmental interests of society, the state and business entities

Obviously, economic factors will remain decisive in the development of urban logistics infrastructure for business. However, most businesses have realized that without a social function to ensure the public interest, it is impossible to successfully develop even local markets, not to mention the most important elements of the sectoral economy. The environmental aspect is also becoming a key here in terms of ensuring public interests in the segment of urban ecology, as well as public access to environmentally friendly resources.

Considering a compromise between environmental requirements and economic interests, the state must still put environmental factors above and do everything in its power to make business structures do the same. The interest of society in the greening of the urban environment is obvious. However, despite all the importance of environmental interests, the economic component cannot be neglected either. It is economic interests that are the driving forces of the country's economy and the future depends on their successful implementation. Clearly, the conflict of interests should be resolved on the basis of the development of a multicriteria problem, in which economic and environmental factors will be the criteria of optimality.

The optimal decision on the urban development, taking into account the compromise between economic and environmental interests of society, the state and businesses will obviously not be the only one, because even in specific conditions there will be a certain zone of optimal solutions. Future scientific and practical studies should be devoted to the definition of such zones of optimal solutions according to certain initial data.

It is obvious that determining the optimal solution for the urban development through the compromise between economic and environmental interests of society, the state and business entities will require taking into account the specifics of the city itself. For example, there are port cities, the ecology of which is negatively affected by the port itself. It should be noted that the ports are very important components of the urban infrastructure of maritime cities. Their impact on the urban environment is very significant, as their operation is provided by vehicles that are part of urban transport flows. As a rule, these are big trucks, which significantly damage the urban infrastructure and cause additional congestion in cities. Also the carbon emissions they emit into the atmosphere can't be forgotten. For the majority of port cities of Ukraine, especially Odessa, Mariupol, Mykolaiv the latter is especially relevant. Emissions are just one of the

harmful factors in port cities. Significant contaminants are lubricants used in the vehicles. The ports also have specialized loading, unloading and other equipment, which also has a negative impact on the environment.

The next key issue remains the pollution of the city waters caused by the ports' operation. This is especially true of bulk ports, where the problem of oil spills remains insurmountable, even in the most technologically advanced ports in the world. Also working with dangerous categories of goods should be mentioned. The requirements for port storage of such cargoes need to be strengthened, albeit given Beirut's sad experience with the detonation of ammonium nitrate, which has been stored without proper maintenance for years. Of course, this is unacceptable, also given that it is by maritime transport the largest volumes of such cargoes are transported and stored in one place.

There are cases of disregarding the violation of the city's ecologic system caused by the port's operation. Meanwhile, this is an extremely acute problem. Ballast water discharges in the coastal zone can be a major environmental problem. There were cases when bacteria in this water multiplied and caused a violation of the ecological balance of the entire water area of coastal cities. On the one hand, the economic losses from such actions are very difficult to assess, and on the other hand, it is difficult to even prove the guilt of a particular shipowner whose vessel was the cause of this. The spread of various algae, the emergence of new fauna can dramatically affect its ecology, in particular the tourism sector. Only following the strict environmental restrictions can partially solve this issue in ports.

Undoubtedly, the biggest negative impact on the urban environment is caused by road transport. The increase in the number of private vehicles has put additional pressure on the city's ecology. This is particularly felt in those cities that have outdated transport infrastructure that is unable to provide sufficient service to the growing traffic flows. Large Ukrainian cities belong to this category. Constant traffic jams in Kyiv, Kharkiv, Odesa, Dnipro, Lviv and other cities have become the norm and last but not least they arise due to the inefficient system of urban traffic organization. The system of organization of urban passenger transport in a number of cities of Ukraine can be considered rather

good or satisfactory, while the organization of cargo flows and private transport can not withstand any criticism. World practice proves that the transfer from private cars to public transport occurs only when passengers are satisfied with the level of mobility while maintaining the values of other important parameters, especially prices. To solve the problem of oversaturation of urban road cargo flows, specialized logistics centers should be built on the outskirts of cities, in addition, the development of more environmentally friendly modes of transport – maritime and rail must be provided. As the best world practices show, the delivery of goods by water and rail can even be provided to the city center. Moreover, in the largest cities of Ukraine, water and rail routes pass through the central parts of cities, and the corresponding infrastructure transshipment facilities are often available there.

Air transport mode has a much smaller impact on urban ecology, but greenhouse gas emissions from aviation are a major global challenge and the aviation authorities continue to fight for reducing them. The impact of airports on the environmental condition of cities is usually much smaller than that of ports, but it is also significant. In addition, appropriate logistics terminals are being built around airports, which also have a negative impact on the environment, and therefore other modes of transport are used to service air flows in one way or another.

Rail connections are also an important component of the urban transport and logistics system of the world's leading countries. An efficient connection between the subway and the city electric train as an organic part of the urban system has been implemented, for example, in German cities. Leading experience also indicates the active use of railways to provide service to cargo flows of cities, which allows to unload urban highways, thereby reducing traffic congestion and as a result decreasing emissions of harmful substances into the atmosphere.

Notwithstanding, the use of particular transport modes and the modality of the two modes of transport have been described, while the most effective will be the integrated development of the entire logistics infrastructure and rolling stock, taking into account all the advantages and limitations. The pandemic has made significant adjustments to the development of the urban logistics system. In particular, a significant drop in passenger traffic caused losses to urban passenger transport. Also

passengers began to use their own transport more frequently due to pandemic restrictions and fears of getting infected in places of mass concentration of people – in public transport. Restoring confidence in urban passenger transport is possible only if the pre-pandemic frequency of traffic is retrieved, along with mass vaccination of the population, and the introduction of advanced innovative means and

measures of logistics optimization. The innovative development of the urban logistics infrastructure should be manifested in the provision of passenger and cargo flows in cities, the implementation of the up-to-date information tools, the implementation of innovative engineering and design, technical and technological solutions, Fig. 3.

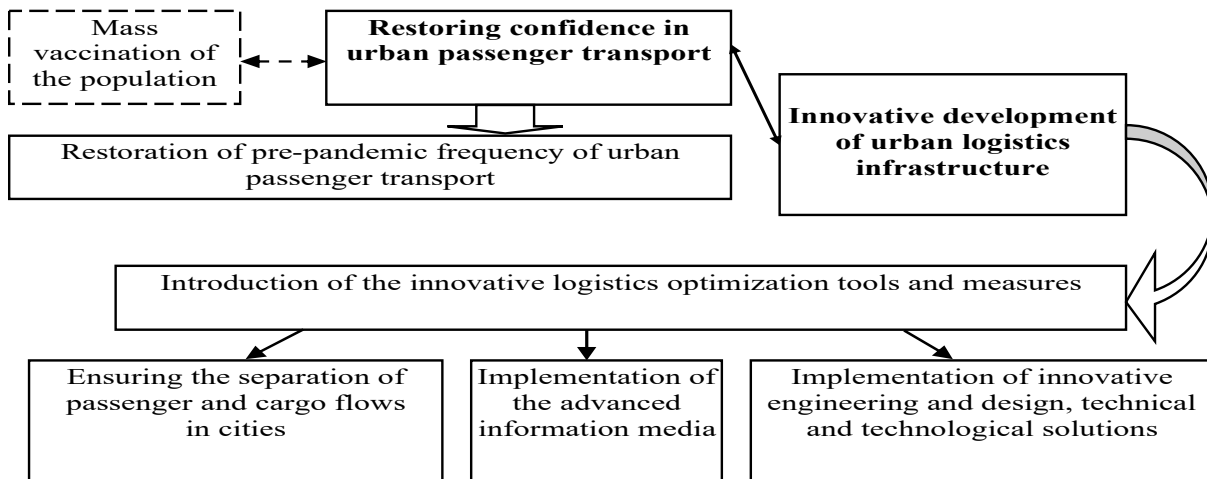


Fig. 3. The scheme of innovative development of urban logistics infrastructure under pandemic constraints

In general, it should be noted that the problem of logistics infrastructure optimization must be solved in a comprehensive way, and this complex and multifaceted solution with the achievement of the synergy effect will be the key to success. The effectiveness of its solution is also directly related to the restoration of the pre-pandemic frequency of urban passenger transport.

4. Conclusions

Within the framework of the study, a critical analysis of scientific researches of domestic and foreign authors was carried out, which revealed the presence of direct causal links between technogenic load on the environment, which is directly affected by the urban logistics infrastructure, and the state of public health. It is also interesting to view the socio-cultural development of society, among other factors, as one that is able to intensify economic activity. It was identified that researchers of urban ecology emphasize the existence of new challenges requiring further in depth study. Also there is a need to integrate urban environmental researches with urban economy and urban planning, as well as with general

ecology and biology in implementing a systematic socio-environmental approach. It should be noted that the study on the creation of a comprehensive concept of urban development based on the application of the concepts of urban megaregion and the continuum of urban planning is extremely promising. It was outlined that all these studies require updating and taking into account the impact of the spread of COVID-19. It was determined that only compromise management of environmental and economic factors is the key to successful development of urban logistics infrastructure.

The problem of environmental safety of cities is solved by creating an effective network of urban public transport and effective planning of urban infrastructure. The paper identifies and describes the impact of the environmental aspect on the dynamics of transport flows. The inevitability of a conflict between the economic and environmental interests of society, the state and economic entities was defined, and the infrastructural development of the city will depend, in particular, on the effectiveness of its solution. To theoretically substantiate solving the problem, a general scheme for determining the optimal solution for the development of the city, taking into account the compromise between

economic and environmental interests of society, the state and businesses was proposed.

The specifics of different modes of transport and cities were studied in detail, which made it possible to offer a scheme of innovative development of urban logistics infrastructure under pandemic constraints. It was noted that the innovative development of the urban logistics infrastructure should be ensured by the development of passenger and cargo flows of cities, the introduction of the advanced information tools, as well as the implementation of innovative engineering and design, technical and technological solutions.

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