ASSESSMENT OF SOCIO-ECOLOGICAL EFFICIENCY OF TRANSPORT AND LOGISTICS ACTIVITY

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Abstract. Improving the environment, like the quality of life, comes at a cost. In this regard, scientists and practitioners of the developed countries of the world raise the problem of finding a compromise between the results of economic activity, in particular transport, and the cost of measures to mitigate its negative consequences for the environment and society. Overcoming this problem lies in the search for optimal socially responsible economic solutions that can balance the economic, environmental and social needs of business, the state and society. The article analyzes the main aspects of the social and environmental activities of transport and logistics companies. A new solution to the methodological problem of analyzing the socio-environmental efficiency of transport and logistics companies through the inclusion of additional private performance indicators is proposed. The expert method determined particular indicators of social and environmental efficiency, on the basis of which the absolute values of the integrated indicators were calculated. They were followed by monitoring of the introduction of environmental principles into the economic activity of 10 transport companies of Ukraine in 2015-2020. This approach allows making scientifically based effective management decisions in the implementation of transport and logistics schemes for the delivery of goods; determine quantitative criteria for evaluating the effectiveness of proposed social and environmental measures. The results of the study showed that the socially responsible management of transport and logistics companies helps reduce the environmental impact of transport services without compromising their quality, cost, reliability, productivity or efficiency.

Keywords: transaction costs, transport logistics, supply chain, profitability, environmental friendliness, efficiency.

Introduction

Only yesterday it was believed that the economy and ecology themselves are opposites, constantly in conflict with each other. The main logistics concepts of supply chains ("door to door", "just in time", etc.) are focused on the quality of service and the time of delivery of goods, which in turn is associated with increased energy costs and environmental pollution.

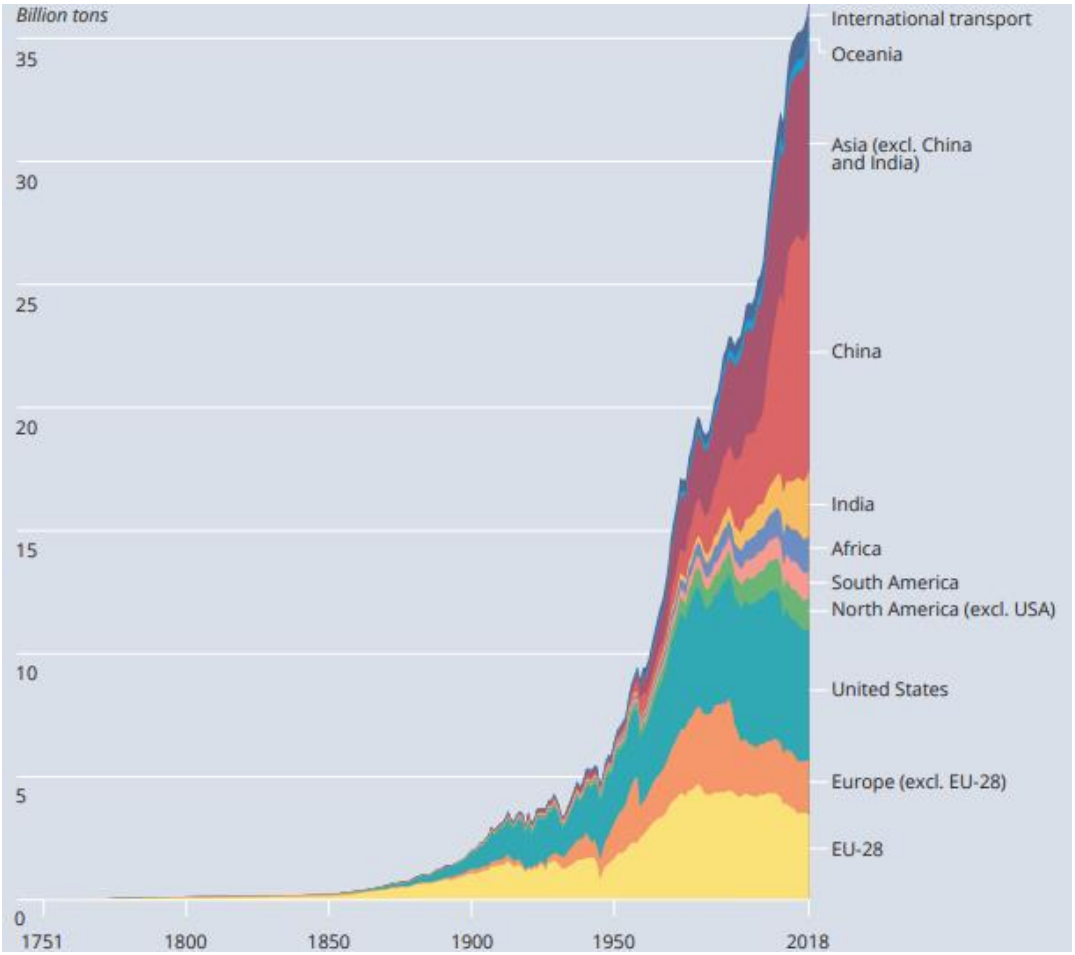
Today, special attention of the world community is paid to reducing greenhouse gas emissions to achieve zero levels with the help of new energy technologies. At the same time, the obligations of states take into account the development of technologies for reducing emissions while simultaneously stimulating economic growth [1]. Accordingly, the development of the concept of "sustainable economy" and the associated changes in environmental requirements encourage business structures to pay more and more attention to environmental management and "green supply chains GrSCM", in which at least several links use environmentally friendly technologies.

It is mostly about green production or procurement and very little attention is paid to the green transport of goods. Perhaps, with the location of suppliers, manufacturers and customers connected in the supply chain at short distances from each other, environmentally harmful transportation can be neglected. However, if the transportation process takes a significant share in the total volume of logistics operations, even in the presence of "green" production, procurement and marketing focused on environmental marketing, it is not entirely correct to classify such a supply chain as "green", from our point of view. According to experts, transport accounts for approximately 14% of the total carbon dioxide CO2 emissions on the planet, transport is the main source of nitric oxide NOx, sulfur oxide SOx and emissions of particulate matter or fine dust [2]. The annual total CO2 emissions from transport in global supply chains are greater than those of any economy in the world (Fig. 1).

In this regard, the introduction of "green" technologies and an adequate mathematical apparatus for measuring their social and environmental efficiency will make a significant contribution to the development of socially responsible transport and logistics activities, and, ultimately, to maintaining a climate on the planet suitable for human life.

It should be noted that the relevance of considering the issue of environmentally friendly logistics arose along with the emergence of the concept of "social responsibility of business", which, in fact, also

has duality and dialectical unity of contradictions. Since the 2000s, scientists from different countries have been conducting a wide range of studies related to various aspects and problems of "green supply chains" [3-8]. At the same time, due to the complexity of the problem and the limitations of the methodological apparatus of any particular discipline, a significant number of issues related to the ratio of economic, social and environmental components of logistics activities remain insufficiently disclosed. All this requires new approaches and interdisciplinary dialogue.



Source: *Carbon Dioxide Information Analysis Center* (*CDIAC*); *Global Carbon Project* (*GCP*)

Fig 1. **Annual cumulative CO2 emissions by region**

The purpose of the article is to solve the methodological problem of improving the quality of the analysis of the socio-environmental efficiency of transport and logistics companies through the inclusion of additional private performance indicators.

Materials and methods

Studies of the works of foreign scientists made it possible to highlight the main properties and directions of "green" logistics. So, according to P. R. Murphy, R. F. Braunschweig and D. Charles, "green" logistics "... directs standard logistics requirements for rationality, efficiency, processing speed and movement of goods, and takes into account environmental protection measures" [9]. H. Vidová, D. Babčanová, K. Witkowski, S. Saniuk "green" logistics (or sustainable logistics) identified with the reduction of environmental and other negative impacts associated with the promotion of goods [10]. A. McKinnon, S. Cullinane, M. Browne, A. Whiteing argue that "green concepts combine environmental thinking in logistical activities for the development of society" [11]. A. O. Seroka-Stolka calls "green" initiatives in logistics strategies that require commitment to the natural environment through voluntary initiatives [12].

Within the framework of these concepts, logistics activities are reduced to a distribution system of goods, which should be carried out on environmental principles. And if we consider transportation

operations separately, then the key tasks to reduce the harmful effects of transport on the environment and society will be:

- reduction of emissions and waste disposal by all modes of transport;
- reduction of energy intensity of transport;
- motivation for the transfer of vehicles to environmentally friendly fuels.

The solution of these problems is directly related to significant financial costs, which consumers are not always ready to compensate and transport and logistics companies do not want to bear at all. For many years it was believed that "logistics activities are characterized only by economic goals to maximize profits or minimize the total cost of goods" [7, p. 529]. At the same time, modern concepts for the development of a sustainable economy show that the introduction of "green" logistics also contributes to increasing the sustainability of supply chains (especially from the point of view of a socially responsible consumer) [13]. Accordingly, the planning of transport and logistics activities requires a balance between economic, environmental and social priorities. The balance consists in determining the optimal solutions in which, at constant (or close to them) costs, the damage to the environment and, accordingly, to society will gradually decrease.

In this regard, we propose to consider all solutions that help reduce the anthropogenic impact of transport processes on the environment and society as social and environmental ones.

We refer to them.

1. Decrease in the total mileage of vehicles when transporting goods at all stages of the supply chain;
2. The introduction of modern information and communication technologies that help reduce costs, improve the quality of processes and increase the transparency of relationships.
3. Consolidation of goods, especially when transporting goods in small batches ("Less-Than-Truckload" (LTL). For long-distance transport to achieve economic and environmental efficiency, small consignments are combined into larger ones.
4. Optimization of operations at the final stage of the transport process. In logistics, there is the concept of "last mile", which is used to refer to the last stage of cargo delivery, i.e. directly to the client. The "last mile" is the most costly for companies in economic terms, as cargo arrives at intermediate points in bulk.

At this stage, social and environmental solutions will be as follows.

- Car sharing. Consolidation of shipments from different suppliers to neighboring stores reduces both costs for companies "changing the business mindset, making it easier to see the economic benefits of an integrated green supply chain" [14, p. 110], and contributes to the reduction of car traffic, which brings positive externalities in solving the environmental and social problems of large cities.
- Routing associated with calculating the time spent by vehicles on the way. Traffic conditions on routes differ significantly depending on the time of the year or day (congestion and traffic jams on popular routes). And if they are not taken into account, then vehicles during peak periods of time will be idle or work not in optimal modes. Qualitative analysis of road conditions and optimization of travel time will allow vehicles to be guided on the roads along which they will move faster, thereby reducing anthropogenic impact on the environment and society.
- Use of environmentally friendly vehicles on the "last mile". Inclusion in this system of intermediate transshipment points, in which the movement of goods from large trucks to environmentally friendly urban trucks of lower carrying capacity will be carried out, which will further improve the quality of environmental management in transport.

With a combination of these approaches, the task of building a transportation model is to optimally route a fleet of vehicles with a fixed load capacity for the delivery of consolidated goods in a certain period of time. Optimization is determined by finding a solution that maximizes profits while minimizing the number of vehicles used and the total travel time, which in turn will bring the company a triple win: reducing the burden on the environment, improving the image and reducing costs throughout the supply chain.

At the same time, as we noted earlier, the introduction of all these measures into economic activity is expensive, and consumers of transport services are not always ready to compensate for their cost. As

a result, we get a social dilemma representing many real economic situations in which the personal interests of economic entities contradict the collective interests of social groups and society as a whole. Describing their nature, P. Collock notes that individual rationality leads to collective irrationality, therefore, the behavior of economic entities based on individual preferences leads to a situation where each entity receives a loss instead of a benefit [15, p. 183].

Therefore, in our opinion, one of the most important tasks of "green" logistics is making decisions that balance the environmental, social and economic interests of business, the state and society. As well as the readiness of business and society, represented by the state, to conduct a constructive dialogue that helps reduce transaction costs to establish the necessary institutional changes (adoption of new norms and rules and enforcement of them) in supply chain logistics. Namely on:

- search for reliable partners;
- contract negotiation and associated measurements or defining the attributes of what is being exchanged;
- enforcement of the agreement;
- fulfillment of the requirements of regulatory legal acts regulating the activities of transport and logistics companies;
- exercising control over the activities of transport and logistics companies.

The laws adopted by the state that determine the rules for the implementation of activities for the transportation of goods, as well as the need to comply with such rules, including the conclusion of contracts for the carriage, employment contracts, accounting, carrying out measures to ensure traffic safety and transport security, significantly affect the structure costs of the transport and logistics company. At the same time, the distribution of resources, benefits and costs is affected not only by those rules, the content of which is directly the transfer of benefits from one carrier to another (for example, tax laws or rules for determining the fare for heavy vehicles), but also those that do not directly relate to organizational issues transportation, for example, the establishment of additional licensing requirements, including environmental ones. A correspondingly high level of transaction costs often means that transactions that are potentially profitable are nonetheless conducted or occur less often and therefore their effective outcomes cannot significantly affect the market [16].

To make such decisions, a qualitative analysis and monitoring of the social and environmental performance of a transport and logistics company, reflected in monetary terms, is required. It can be done by comparing the overall social and environmental benefits of the activities of a transport and logistics company and the transaction costs associated with them. Moreover, the problem of transaction costs of transport and logistics systems must be considered through the prism of "optimization and improvement of institutional factors, and not their total minimization, which can negatively affect their functioning and development" [17, p. 178]:

- profit of a transport and logistics company from establishing effective interactions associated with the introduction of new rules and norms for the transportation of goods with participants in institutional changes;
- the costs of establishing effective interactions between a transport and logistics company and participants in institutional changes;
- coefficient of efficiency of social and environmental costs.

At the same time, the calculation of the value of the profit of a transport and logistics company is carried out according to the method of discounting costs and income that affect the increase in social and environmental efficiency from the institutional changes carried out:

$$P = \sum_{t=1}^{T} \frac{\left(DK_t - BE_t - BT_t\right) + \left(DCE_t - BCE_t\right)}{\left(1+r\right)^2} - C, \quad (1)$$

where DK_t – income from commercial activities;
BE_t – transformational (economic) costs;
BT_t – transaction (non–economic) costs;
DCE_t – social and environmental income;
BCE_t – social and environmental expenses;

C – value of the lost natural resource;
t – time period for which the calculation is made;
r – discount rate;
T – period of time during which the consequences will occur from the impact of the establishment of effective interactions between the transport and logistics company with the participants in institutional changes on society and the environment.

Based on Formula 1, it is possible to construct a coefficient of social and environmental efficiency, showing the ratio of discounted social and environmental income to discounted social and environmental costs:

$$K = \frac{\sum_{t=0}^{T} \frac{DK_t + DCE_t}{(1+r)^2}}{\sum_{t=0}^{T} \frac{BE_t + BT_t + BCE_t}{(1+r)^2}}, \quad (2)$$

- with $K = 1$, the company's activities in the market of transport and logistics services will be neutral in relation to society and the environment;
- when $K > 1$, the company's activities should be considered as economically sound, socially and environmentally sound;
- with $K < 1$, the company's activities are ineffective, both in terms of social and environmental costs and benefits, and in terms of transaction costs incurred by it and society for their implementation [18, p. 167].

In other respects, the "K" indicator is rather generalized and expresses only a general vision of the development strategy of a transport and logistics company based on the principles of "green" logistics. In our opinion, the methodological problem of assessing the socio-environmental efficiency of transport and logistics companies needs to expand the boundaries of the analysis through the inclusion of additional private performance indicators.

Results and discussion

In our study, to assess the socio-environmental efficiency of transport and logistics companies, we propose first to select by expert means, and then use private performance indicators in monitoring.

The reliability of such an analysis depends on the possibility of constructing an adequate system for the unambiguity of interpreting the results of mathematical processing of a certain group of particular target indicators in order to prevent and avoid ambiguous conclusions, contradictions in the views of individual experts on identifying the state of the object of study.

To do this, we compiled a questionnaire and conducted a survey among experts in the transport and logistics sector (heads of transport and logistics enterprises). Their analysis made it possible to single out four groups of partial indicators of the effectiveness of the social and environmental activities of transport and logistics companies and two groups of indicators of the effectiveness of institutional changes in this area. In each group, three main indicators were identified, which were most often indicated by the respondents, while indicators that were similar in meaning were combined (Tables 1 and 2).

The absolute values of the generalizing integrated indicators were calculated using the formulas:

$$E_{sum1} = \alpha_E^1 \times \sum_{i=1}^{n} \beta_i^{E1} \times X_j^{E1} + \alpha_E^2 \times \sum_{i=1}^{n} \beta_i^{E2} \times X_j^{E2} + \alpha_E^3 \times \sum_{i=1}^{n} \beta_i^{E3} \times X_j^{E3} + \\ + \alpha_E^4 \times \sum_{i=1}^{n} \beta_i^{E4} \times X_j^{E4}, \quad (3)$$

$$E_{sum2} = \alpha_E^1 \times \sum_{i=1}^{n} \beta_i^{E1} \times Y_j^{E1} + \alpha_E^2 \times \sum_{i=1}^{n} \beta_i^{E2} \times Y_j^{E2}, \quad (4)$$

where α_E – weight coefficients of research directions;
β_i – weight coefficients of target indicators in certain areas;
X_j and Y_j – value of particular indicators.

Table 1

Private indicators of the effectiveness of social and environmental activities of transport and logistics companies

Indicator group	Iindicators
Economic efficiency $E_{economics}$	$X11$ – profitability
	$X12$ – labor productivity
	$X13$ – size of capital investment
Environmental efficiency $E_{ecology}$	$X21$ – amount of hazardous emissions into the environment
	$X22$ – % compliance of vehicles with the requirements of international environmental standards
	$X23$ – amount of environmental taxes
Innovative efficiency $E_{innovation}$	$X31$ – return on assets
	$X32$ – number of developed and implemented technologies
	$X33$ – ROI
Social efficiency E_{social}	$X41$ – number of new jobs
	$X42$ – level of wages
	$X43$ – quantity and quality of social communications

Table 2

Private indicators of the effectiveness of institutional changes Table 2 – indicators of the effectiveness of institutional changes

Indicator group	Indicators
Price of "legality"	$Y11$ – reducing the cost of finding information
	$Y12$ – reducing the cost of going through bureaucratic procedures
	$Y13$ – reducing the cost of contract compliance
Price of "illegality"	$Y21$ – official tariff payments
	$Y22$ – fines for illegal activities
	$Y23$ – fines for violation of environmental legislation

Moreover, each of the indicators X_j and Y_j is provided with a level of its significance for the analysis of overall efficiency. To assess this level, you need to arrange all indicators in descending order of their importance so that the rule is fulfilled.

$$r_1 \geq r_2 \geq ...r_n$$

Ranking is done using Fishburne's rule:

$$r_i = \frac{2(N-i+1)}{(N-1)N}. \quad (5)$$

Using the integrated performance indicators defined above, we analyzed the activities of 10 transport and logistics companies in Ukraine that implemented a development strategy based on "green" principles in 2015-2020. And if the indicators of the first four efficiency groups were calculated by formalized methods for describing analytical procedures, based on clear dependencies, using the mathematical apparatus of economic and financial analysis, then the indicators of the last two, taking into account non-formalized dependencies, were built at a logical level using expert opinions and estimates, and therefore may be subjective.

The summary results of changes in the integrated indicators of each group over a five-year period are presented in Tables 3 and 4.

As it can be seen from Table 3, the introduction of environmental principles into economic activities gradually increases the environmental and social efficiency of the company. Economic efficiency comes only in the fourth year of operation, and innovative efficiency decreases every year, which is not surprising, due to the need to constantly update vehicles and cargo delivery technologies. The general indicator of socio-ecological efficiency also gradually increases from 2.5 in the first year to 2.9 in the fifth.

Table 3

Matrix of integrated indicators of the effectiveness of social and environmental activities of 10 transport and logistics enterprises over 5 years

Integrated indicator	**Time of effective interactions, year**				
	1	2	3	4	5
Economic efficiency	0.28	0.29	0.29	0.32	0.34
Environmental efficiency	0.18	0.19	0.21	0.22	0.23
Innovative efficiency	0.31	0.32	0.30	0.28	0.27
Social efficiency	0.22	0.23	0.25	0.29	0.32
Socio-ecological efficiency	**0.25**	**0.26**	**0.26**	**0.28**	2.9

Table 4

Matrix of integrated indicators of the effectiveness of institutional changes for 10 transport and logistics enterprises over 5 years

Integrated indicator	Time of effective interactions, year				
	1	2	3	4	5
Price of “legality”	0.11	0.11	0.12	0.12	0.13
Price of “illegality”	0.1	0.1	0.1	0.09	0.09
Effectiveness of institutional change	**0.11**	**0.11**	**0.11**	**0.11**	**0.11**

In contrast to the performance indicators of the social and environmental activities of transport and logistics companies, there is practically no growth in the performance indicators of institutional changes (it has not changed over five years). And if the integrated indicator of the “price of legality” group has a slight upward trend, then the indicator of the “price of illegality” group not only does not improve, but has been decreasing over the past two years. Which, in our opinion, indicates the absence of specific measures to combat illegal carriers at the state level, and the presence of “institutional traps” in the transport and logistics sector, in the form of a shadow economy, corruption, rent-seeking behaviour of participants, weakness of the state apparatus, etc.

Conclusions

1. Underestimation of natural resources and environmental damage from transport and logistics activities leads to a distortion of indicators of economic development and progress, which, in turn, leads to the choice of an inefficient socio-economic direction for the development of the transport industry.
2. Reducing the environmental impact of transport and logistics activities can demonstrate the desire of companies for socially responsible behavior, and support for institutional changes in this area by the state is about establishing interactions between business and society, and the interaction of these factors is about finding a compromise between efficiency and environmental friendliness.
3. Socially responsible management of transport and logistics companies helps reduce the environmental impact of transport services without compromising their quality, cost, reliability, productivity or efficiency. It is possible to increase the efficiency of “green” logistics on the basis of an adequate economic consideration of environmental and social factors.
4. In the work, four groups of private indicators of the effectiveness of the social and environmental activities of transport and logistics companies and two groups of indicators of the effectiveness of institutional changes are identified by the expert method. On their basis, the absolute values of generalizing integrated indicators of social and environmental efficiency were calculated, which reflect the amount of benefits received by the logistics company and society from the financial resources spent to improve social and environmental efficiency and transaction costs to establish effective interactions.
5. Monitoring of the implementation of environmental principles in economic activities, carried out in 10 transport companies of Ukraine during 2015-2020 by evaluating private performance indicators, showed trends towards improving both environmental and social indicators, and

subsequently the economic efficiency of their activities. At the same time, there is no growth in the effectiveness of institutional changes, which, according to business, is an indicator of the insufficient desire of the country's state bodies to establish effective interactions in the transport and logistics sector.

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