

РОЗДІЛ 1. КОНЦЕПТУАЛЬНІ ЗАСАДИ ЕКОЛОГІЗАЦІЇ ЛОГІСТИЧНОЇ ДІЯЛЬНОСТІ

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1.1 European methodology for monetizing external costs of road transport

Annotation. The transport of people and goods is essential for the development of a country, the activities of both freight and passenger logistics generate lots of negative externalities, which are rarely considered by the authorities in the private and public sectors. In general, an externality occurs when an agent performs an action from which effects are derived that have an impact in the form of benefits or costs to other agents. Road transport is responsible for the generation of such externalities, such as congestion, barrier effects, road crashes, oil dependence, and water and air pollution.

The countries of the European Union have long been engaged in converting indirect losses from transport into financial units. Handbooks of 2008, 2014 and current version of 2019 are devoted to financial assessment of negative external effects of road, rail, maritime and air transport in the EU. Resulting values help calculate the value of external costs for different types of transport for different road situations, types of vehicles, fuel, etc., and for different units of measurement of productivity (costs per 1 tkm, 1 pas-km, 1 vehicle-km). In such way, European countries have a methodology and practical mechanism for estimation of all the main types of socio-ecological costs and losses from transport, namely traffic accidents, air pollution, climate change, noise, traffic jams and congestions, "well-to-tank" emissions, damage to the habitat and other categories of external costs (for example, soil and water pollution).

Since external costs usually do not have market prices available to them, alternative valuation methodologies are suggested to be used: 1) Damage cost approach (Methods of stated preferences and Methods of revealed preferences); 2) Method of avoidance costs; 3) Method of replacement cost; 4) Methods of transferring values.

1.1.1 Externalities of transport

The infrastructure of transport is an essential component of freight and passenger mobility. Although the transport of people and goods is essential for the development of a country, the activities of both types of transport (freight and passengers) have another characteristic in common, and that is the generation of several negative externalities, which are rarely considered by the authorities in the private and public sectors [1]. In general, there is an accord in literature that road transport is responsible for the generation of several negative externalities, such as congestion, barrier effects, road crashes, oil dependence, and water and air pollution [2].

An externality occurs when an agent performs an action from which effects are derived that have an impact in the form of benefits or costs to other agents [3]. Among such external agents there may be indirect participants in the transportation process, intermediaries, as well as residents who are not involved in the movement process and natural environment as a whole. Within economic science, the question of the relationship between human activity and the environment has been addressed since about the middle of the twentieth century and is associated in particular with the economist Arthur Cecil Pigou. He was the first to define the so-called social costs, that is, externalities, or external costs, ‘spillovers’ that are not paid by their originator. Pigou proposed that externalities should be addressed by taxation (i.e. by adding the external costs to the internal costs of the producers of the externalities), but the issue itself is not so trivial [4]. The pitfalls can be summarised as follows:

- internalisation of externalities may bring so-called opportunity costs, that is, foregone revenues from activities that will not be realised due to higher taxation,
- the effectiveness of internalisation of externalities using Pigou taxes depends strongly on the elasticity of demand (e.g. for individual transport) and if demand is inelastic, the internalisation effect will be weak [5, 6],
- internalisation may reduce the competitiveness of the economy and undermine economic growth and, as a consequence, paradoxically reduce state budget revenues,

CONCEPTUAL PRINCIPLES, METHODS AND MODELS OF GREENING LOGISTICS ACTIVITIES

- a non-negligible factor in the internalisation of externalities is transaction costs, which in the case of transport leads to internalisation being addressed by state intervention, but this also raises additional transaction costs.

The basic division is on positive and negative externalities. Positive externalities are external economies; that is, they increase production or benefit for such externalities, which are influenced by the externality. Negative externalities, however, decrease benefit of the other part and mean a negative external economy. As an example, we can mention frequent forms of pollution of the environment. Externalities can be further sorted according to the way of their origin as pecuniary and technological. Pecuniary externalities arise due to mutual interaction of economic activities within the national economy and work via changes of price relations and do not disturb allocation market function. Technological externalities, which arise through the mediation of specific features of concrete activities, are problematic. They do not work through the price system while they spoil activities and production and utility functions of other subjects. Besides, externalities are divided into partial (influencing a limited number of subjects) and global (of the impact on a big number of subjects) or into mono-dimensional (an externality works in the same field where it origins) and multi-dimensional ones. Generally, we can say that externalities influencing the environment belong among multi-dimensional externalities [7].

As mentioned previously, transport is famous for generating several negative externalities such as congestion, road traffic crashes, energy dependence, road damage, and air and water pollution [8, 9, 10]. However, there are other types of negative externalities such as visual blight, vibration damage, barrier effects, and others that could affect the quality of life of people if not treated adequately [11, 12]. In the Figure 1, the negative externalities associated with transport can be seen.

1.1.2 History of European monetization of external costs of transport

The countries of the European Union have long been engaged in converting indirect losses from transport into financial units. In relevant studies, reference books, instructions and regulations, such costs are called external.

CONCEPTUAL PRINCIPLES, METHODS AND MODELS OF GREENING LOGISTICS ACTIVITIES

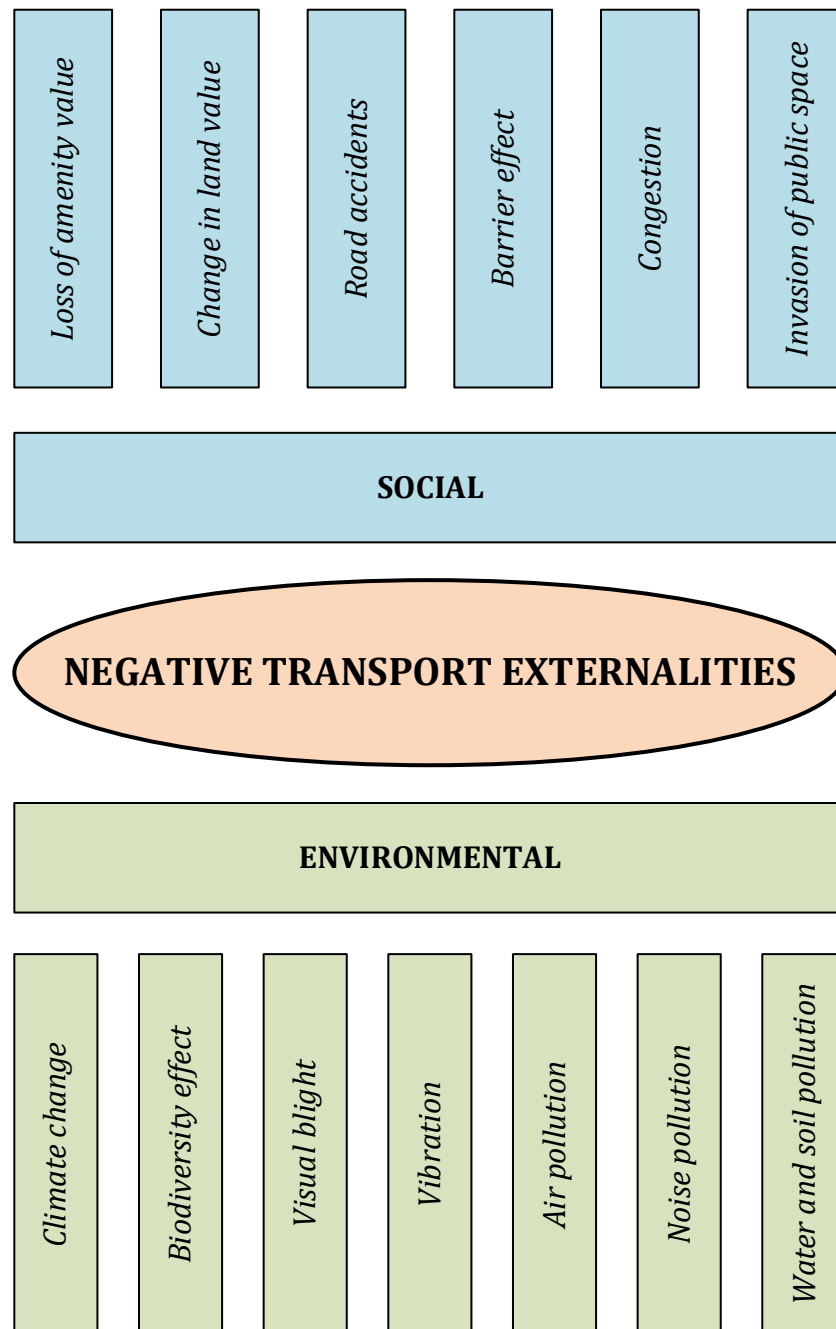


Figure 1. The most common negative social and environmental externalities of transport

In 2008 the European Commission commissioned the first Handbook on External Costs of Transport, as part of the IMPACT study [13]. The 2008 Handbook focus was on marginal external costs of transport as a basis for the definition of internalisation policies (in line with the marginal social cost pricing principle). It covered all main

external cost categories, including air pollution, climate change, noise, accidents and congestion.

In 2014, the Handbook was updated to reflect new developments in research and policy [14]. Furthermore, the scope was broadened: next to the external costs of transport, infrastructure wear and tear costs for road and rail transport were covered as well.

The latest existing 2019 Handbook [15] is an update to the 2008 and 2014 versions. It considers not only marginal external costs, as was the focus of previous Handbooks, but also total and average external transport costs across the EU, Switzerland and Norway. In addition, data on external costs were prepared for some non-European countries to compare with European figures.

The purpose of the Handbook is to provide information on how to obtain preliminary estimates of all major external transport costs at three levels:

- Methodological level: analyze and apply modern methods of estimating various external transport costs.
- Input values: recommend output parameters for estimating external transport costs
- Resulting values: calculate the value of external costs for different types of transport for different road situations, types of vehicles, fuel, etc., and for different units of measurement of productivity (costs per 1 tkm, 1 pas-km, 1 vehicle-km).

1.1.3 Main categories of external costs of road transport

The current version of Handbook on the external costs of transport [15] covers all the main types of socio-ecological costs and losses from transport:

- traffic accidents;
- air pollution;
- climate change;
- noise;
- traffic jams and congestions;
- "well-to-tank" emissions;

CONCEPTUAL PRINCIPLES, METHODS AND MODELS OF GREENING LOGISTICS ACTIVITIES

- damage to the habitat;
- other categories of external costs (for example, soil and water pollution)

(Fig. 2).

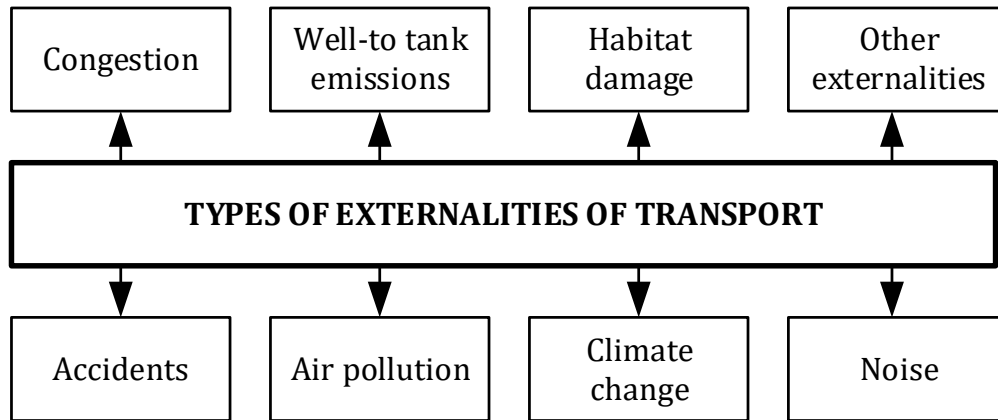


Figure 2. Types of socio-ecological costs and losses from transport

Transport infrastructure costs are also addressed in a complementary study [16].

The methodology covers road transport, rail transport, inland waterway transport (IWT), maritime transport and aviation. The total and average cost values obtained for the vehicle categories are shown in Table 1.

Table 1. Covered modes of transport and types of vehicles

Road transport	Railway transport	Inland water transport	Sea transport	Air transport
- Passenger car - Motorcycle - Bus - Coach - Light commercial vehicle (LCV) - Heavy-goods vehicle (HGV)	- High-speed passenger train - Passenger electric train - Passenger diesel train - Electric freight train - Cargo diesel train	- Inland vessel	- Freight vessel - Ferry	- Passenger aircraft

CONCEPTUAL PRINCIPLES, METHODS AND MODELS OF GREENING LOGISTICS ACTIVITIES

The following designations are accepted:

- Light commercial vehicle (LCV) is for load capacity up to 3.5 tons;
- Heavy-goods vehicle (HGV) is for load capacity of more than 3.5 tons.

For road transport, rail transport and inland waterway transport, input and output values are calculated for all EU-28 countries, Norway, Switzerland, Canada, USA and Japan.

For maritime shipping and aviation, indicators of external costs (output values) are provided only at the level of individual airports and seaports.

Data on road transport performance are taken from Eurostat [17] according to the principle of national affiliation, i.e. transport activity is distributed by country where the vehicle is registered. It should be noted that for Ukraine there is a lack of statistical data that would make it easy to apply the methodology of the Handbook for this country. In particular, the problems of obtaining data for estimating losses from road accidents and congestion costs in Kyiv were studied in [18, 19].

All inputs and outputs in [15] are for 2016. If some data for 2016 were missing, data from the last year (mainly 2015) were used.

Data from sources where price levels were used for other years are converted to the price level of 2016 using the corresponding indicators of the price index [20]. In addition, all financial indicators are adjusted for differences in purchasing power between countries (using Purchasing Power Parities, PPS) so that direct comparisons can be made between countries [21]. This means that all financial indicators are given for the average price level in the 28 EU countries.

To adapt the values of the Handbook for Ukraine, national values of purchasing power should be used (for example, using the values of GDP, PPP [22]). In some studies, the cost values recommended by the Handbook were reduced for Ukraine using a coefficient calculated on the basis of the difference in average wages in Ukraine and EU countries [19].

1.1.4 Total, average and marginal external costs of transport

External costs (EC), also known as externalities, occur when the social or economic activity of one person (or group of people) affects another person (or group of people), and when this effect is not fully taken into account or compensated by the first (group of people). In other words, external transport costs are generally not borne by the user of the transport and therefore are not taken into account when they accept the transport and delivery cost calculation. External transport costs refer to the difference between all economic-social-ecological costs of society (ESEC) in connection with the provision and use of transport infrastructure and the costs directly borne by the transport user (direct costs - DC). Due to the internalization of these costs, external factors become part of the decision-making process of transport users. This can be achieved through regulation (i.e. command-and-control measures) or by providing appropriate incentives to transport users, namely through market-based instruments (e.g. taxes, charges, emissions trading, etc.).

The following types of EC are distinguished:

1. Total external costs – all costs within geographical boundaries (for example, the EU28 or a certain country) caused by a certain type of transport (in billions or millions of euros).

2. Average external costs - EC per unit of transport work (€-cent/pass-km, €-cent per tkm and/or €-cent/vehicle, €-cent/LTO for aviation, €-cent per port call for sea transport).

3. Marginal external costs - EC arising in connection with additional transport activities (for example, in connection with the involvement of an additional transport unit in the flow of cars). In the short run, these costs are associated with constant infrastructure capacity, while in the long run marginal costs take into account its expansion. Short-run marginal cost is the focus of [15].

For some types of EC (for example, air pollution, climate change), the values of average and marginal costs are approximately the same and do not depend on the density of traffic flow. This is logical, since a car entering a dense traffic flow emits the same amount of pollutants into the atmosphere as a car entering a sparse traffic

CONCEPTUAL PRINCIPLES, METHODS AND MODELS OF GREENING LOGISTICS ACTIVITIES

flow, other conditions being the same (location, speed, etc.). However, for other externalities (such as road accidents, noise and congestion), the costs depend on the density of the traffic flow. For example, a car entering a free-flowing road will result in marginal ECs that are significantly lower than the average ECs from traffic jams. However, when a vehicle enters the traffic flow at a time when the road's carrying capacity is almost exhausted, it will cause marginal ECs that are much higher than the average costs.

Thus, for the analysis of EC and the benefit of building a new road, the noise costs are best estimated by the average values of the costs (since the road situation is virtual). On the other hand, it is better to use marginal EC indicators for the analysis of EC and the benefit of widening the road from two to four lanes, since the effectiveness of changing the existing road situation is evaluated.

As mentioned above, external costs are the difference between social and private costs. Table 2 provides an overview of social and external costs by the main categories of externalities.

Table 2. External effects of different expenditure categories

Category of costs	Social costs	External costs
Expenses caused by congestion and infrastructure shortages	- Delay, incorrect travel time and/or arrival time - Additional operational costs - Unrealized economic activity	Additional costs imposed on all other transport users and society, excluding own additional costs
Expenses caused by accidents	- Material costs - Medical expenses - Production losses - Suffering and grief	The part of social costs that is not taken into account when predicting own and collective risks and is not covered by insurance (third-party)
Environmental costs	- Health expenses - Material damages - Damage to the biosphere - Long-term risks, etc.	The part of social costs that is not taken into account (not paid)

CONCEPTUAL PRINCIPLES, METHODS AND MODELS OF GREENING LOGISTICS ACTIVITIES

With regard to costs related to congestion and shortages, only additional costs to other transport users and society are considered external in [15]. Own costs (for example, additional travel time or fuel costs) are not taken into account in the estimation of congestion charges.

Part of the social costs associated with transport accidents is internalized by the transport user (as they take into account their own risk of an accident when deciding on transport) or by insurance companies. As for traffic jams, part of the total and average accidents is caused by the same group of agents that cause these accidents. For environmental costs, external and social costs are the same, except in the situation where part of the social cost is paid.

1.1.5 General methodologies of externalities assessment

Since EC usually do not have market prices available to them, alternative valuation methodologies must be used to quantify them.

1. Damage cost approach. To estimate external costs, economists prefer to use an approach based on the cost of damage [23]. This approach assesses all damages caused to individuals due to the existence of external factors. Willingness to pay (WTP) of individuals to partially avoid losses, or willingness to accept (WTA) losses is used as an indicator of individual preferences.

There are several methods of assessing willingness to pay, which can be divided into two categories:

1) Methods of stated preferences (SP), in which respondents are asked to name their willingness to pay or willingness to accept in order to avoid the harm of external factors. Stated preference methods can take two forms: conditional evaluation (using questionnaires or surveys where respondents are asked directly about their willingness to pay) and choice experiments (where respondents are asked to choose the best option from a variety of packages, and willingness to pay is implied indirectly).

2) Methods of revealed preferences (RP) determine the monetary value of external effects from operations in other economic markets. The most commonly used method of identified benefits is the hedonic price method, which uses the difference in prices

in the housing market to estimate the willingness to pay to reduce traffic noise or emissions. The main strength of revealed preference methods is that they are based on actual market behavior where the willingness of individuals to pay to avoid certain externalities can be observed.

2. Method of avoidance costs. The cost-of-avoidance method determines the EC by determining the costs of achieving a specific social policy objective (e.g. the EU's CO₂ reduction targets [24]). Based on the corresponding cost curve, the minimum costs necessary to achieve this goal are estimated.

An approach based on prevention costs is particularly useful when damages caused by external factors are uncertain and/or difficult to measure.

In [15], the CO₂ price used to calculate the external costs of climate change is derived from the prevention cost method.

3. Method of replacement cost. The replacement cost approach is based on the elimination of adverse consequences caused by the externality. In this Handbook, the replacement cost approach was used to estimate the cost of environmental damage. This approach is often used to estimate external costs for which there is no reliable data on damages or the cost of prevention.

Methods of transferring values. The input and output values estimated in this Handbook are compiled from various studies that estimate willingness-to-pay values for various externalities under specific conditions and over a specific time period. The value transfer procedure is an alternative to carrying out evaluation studies in different Member States and countries. The value transfer approach can be used to transform the input and output values given in this Handbook for other countries or other time periods.

There are different approaches to transferring values [25]:

- transformation of values (simple unit transfer of values and unit transfer of values with income adjustments);
 - transformation of functions (transfer of benefit function and meta-analysis)
- (Fig. 3).

CONCEPTUAL PRINCIPLES, METHODS AND MODELS OF GREENING LOGISTICS ACTIVITIES

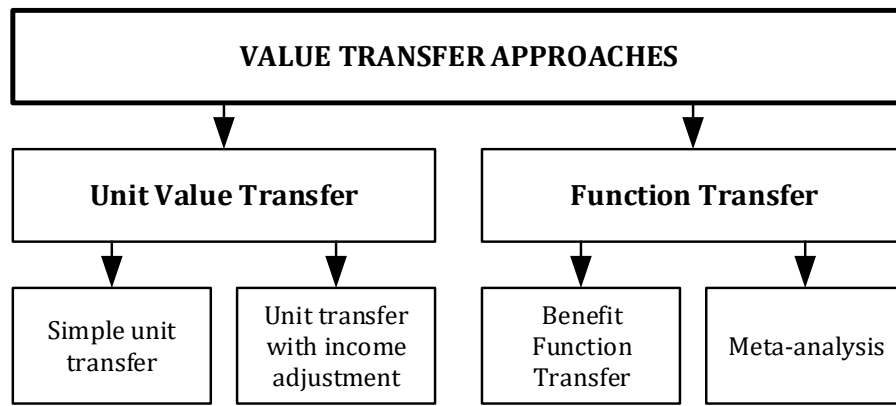


Figure 3. Value transfer approaches

The procedure for transferring values is to adapt the data obtained for the original location to the new location. This can be a straight transfer (simple transfer of values) or with small adjustments such as exchange rate, inflation and income (transfer of values with income adjustment). The approach based on the transfer of the benefit function consists in estimating a function that establishes a relationship between the values and certain factors at the source site to predict the values at another site (obtaining a regression).

Although theoretically the benefit function transfer approach is better because it takes into account more information, it is generally more difficult to apply in practice because it requires significant additional information about the characteristics of the studied and the new place. For example, willingness to pay for noise abatement can be measured by income, population density, and age. To obtain willingness to pay for noise abatement in another region, relevant statistics on income, population density and age must be collected.

Income-adjusted value transfer is preferable to use because of its simple, transparent, and reliable results. This approach is used in [15].

The transfer of values involves taking into account the following factors:

- 1) Differences in prices. It is recommended to use exchange rates adjusted for Purchasing Power Parity to take into account the cost of living. If necessary, adjustments may also be made for differences in the cost of living between regions of the same country.

2) Income difference. The general approach is to multiply the adapted value by the ratio of income in the country of origin to income in the country of adaptation:

$$WTP_{PS} = WTP_{SS} \left(\frac{I_{OS}}{I_{SS}} \right)^{\varepsilon},$$

where WTP_{PS} - willingness to pay adapted to the new region; WTP_{SS} - willingness to pay in the studied region; I_{OS} and I_{SS} - income in the new and studied regions, respectively; ε is the elasticity of willingness to pay according to income.

In [15], income is defined as GDP per capita adjusted for PPP. For income elasticity, a value of 0.8 is recommended, based on the conclusion of the OECD (Organization for Economic Co-operation and Development) that the income elasticity of willingness to pay for goods related to the environment and health is 0.7-0.9.

3) Other differences. For example, road accident losses must be adjusted according to accident risk factors.

Transfer of values is used as a transfer of input and output values between countries, as well as over time. For this, the following adjustments must be made:

1) Difference in price level. Consumer price indices (CPIs) should be used for this purpose.

2) Income difference. Income levels usually increase over time. This means that the willingness to pay is also increasing. The Guide recommends using the same elasticity for spatial and temporal value transfers (e.g. 0.8).

1.1.6 Solutions to reduce negative externalities of road transport

The most commonly used solutions to improve the situation with high external costs of road transport are mainly related to the following tools:

1. Pigovian taxes. Pigovian taxes are one solution used for correcting negative externalities caused by road transport. By increasing the cost of using vehicles, it is possible to reduce consumption to an economically optimal level while raising tax revenue. This is achieved through the use of fuel taxes and road taxes. Which are

intended to raise revenue for infrastructure investment and repair [26]. In the case of carbon taxes, revenue is used for investment in environmentally friendly initiatives [27].

2. Congestion pricing. Major cities such as London and Stockholm have introduced congestion pricing in order to reduce traffic and pollution in their city centres. This is implemented as a toll on automobiles entering the city centre during peak hours [28]. This toll aims to correct the negative externalities and change consumer behaviour, by making consumers more aware of the costs induced by their consumption. Congestion pricing is an efficient way at reducing traffic externalities, as monitoring technology allows prices to adapt to changes in traffic levels. This added toll reduces congestion, encourages the use of public transit, and raises revenue from tolls [29, 30].

3. Subsidizing alternatives. Many governments have begun subsidizing electric vehicles with the intention of taking into account the positive externality that electric vehicles contribute to the environment. This has been implemented through the use of tax credits, purchase rebates, and tax exemptions [31]. In the United States, the purchaser of a new electric vehicle will receive a tax rebate anywhere between \$2500 to \$7500 [32]. These subsidies reduce the cost of Zero-emissions vehicle and as a result increase demand. By incentivizing consumers to reduce their purchases of petrol vehicles in favour of electric cars, there is a decrease in negative externalities associated with emissions.

4. Automotive industry regulation. The use of emission standards on automobiles, reduces the amount of pollutants emitted by new automobiles thus reducing negative environmental externalities. This is an important piece in regulating automobile externalities, as emission levels per litre of gasoline consumed are not reduced by fuel taxes [33]. Emission limits are based on mass of automobiles with heavier vehicles having higher limits. Manufacturers who miss this target are charged with increasing costs for each gram of additional pollution [34].

CONCEPTUAL PRINCIPLES, METHODS AND MODELS OF GREENING LOGISTICS ACTIVITIES

It should be added that in the context of road transport, there is mostly talk of negative externalities, which is undoubtedly necessary, but there is very little discussion of positive externalities, the contribution of transport to country's economic growth (and therefore positive GDP growth). For example, any transport activity, on the one hand, is associated with negative externalities, but, on the other hand, brings many positive effects. Investments in infrastructure, repair and timely maintenance of roads always positively correlate with the country's GDP [35, 36, 37], although it implies a greater freight and passenger turnover, which inevitably increases the negative externalities from transport [38]. The positive effect of improving transport infrastructure may not be immediately noticeable and usually manifests itself in the medium term, especially in the context of transit and external economic flow.