The economic category of time in the context of the analysis of transport projects: theoretical aspects and assessment tools

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Abstract. **Research background:** Swedish economist S.B. Linder considered time as the rarest resource, for the preservation of which people are willing to pay more and more. The problem of monetized evaluation of the benefits of reducing travel time has been relevant for the transport economy since the 1960s. The article is devoted to the study of the specifics of the time resource in modern socioeconomic systems and the analysis of approaches for assessing the benefits of changing time costs. **Purpose of the article:** To make a retrospective analysis of the phenomenon of time in economics, to investigate the evolution of methodological approaches to the assessment of time resources, to uncover contradictions between the fundamental ideas about the distribution of time resources and methods for assessing the benefits of changes in time costs. **Methods:** The methods of systematic, retrospective and comparative analysis are used in the paper. **Findings & Value added:** The conclusions obtained in the course of the study allow us to expand and concretize the methodology of economic assessment of transport projects. There are identified and systematized factors that determine the need for differentiated accounting of changes in the value of reducing travel time for passengers, which ultimately determines the demand for transport services. **Keywords:** economic category of time; value of time reduction; passenger transport; free time.

1 Introduction

If we consider the development of economic thought in retrospect, we can identify several stages, each of which differently considered the category of time and the relationship of this concept with the course of economic processes. The phenomenon of time was studied through the analysis of economic phenomena in statics and dynamics, and much later began to be considered as an independent resource element that determines economic activity.

Initially, economics was engaged in the study of various processes in statics, that is, the temporal component was actually ignored: phenomena were examined at certain moments, which were not connected with either the past or the future, and different variables were assumed to be constant. For example, in the original formulations of the law of supply and demand the concept of time was neglected, respectively, the variables of the model were

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analyzed, all other things being equal, in an indefinite period n.

Further development of scientific thought determined the study of economic phenomena from the point of view of their dynamics, that is, in this case, the processes under consideration were related to a specific time period. For example, D. Ricardo's theory of interest and return on capital is based on how long a borrower possesses the funds. Another example of economic dynamics is the discounting of cash flows, when the value of money is related to a certain point in time. Therefore, the same variable under consideration can take different values depending on the time period. At this stage of the development of economic thought, the category of time was considered as a factor determining economic activity. Thus, there was a methodological transition from considering time as a passive parameter to regarding it as an active variable of economic models. An additional argument confirming the change in the role of the time factor in economic research is the emergence of the theory of economic cycles, which initiated the study of economic processes from the perspective of the duration of time periods: in the short, medium and long term.

The appearance of the first studies analyzing the category of time as an economic resource marked the beginning of the next stage of studying this phenomenon, which subsequently led to significant changes in the paradigm of economic science. The first attempts to study economic processes from the perspective of time resource accounting were made by K. Marx, who used working time to express indicators of economic activity. A fully fledged study devoted to the specifics of the category of time as an economic resource was G. Becker's work "A theory of the allocation of time", in which it was argued that household members strive to maximize the usefulness of time by rationally distributing it between work and household labour. G. Becker stated that the time resource is a strict limitation of economic activity, and individual consumer satisfaction does not come from the goods themselves, but from the "final goods", the cost of which includes not only the purchase costs, but also the time required for the consumption of this product. For example, eating involves not only paying for groceries, but also the time needed to buy food, prepare it and then eat it. Thus, the methodological approach to the analysis of economic activity, taking into account the limitations of the time resource, contributed to the "materialization" of time: time plays the role of a "fully fledged" economic resource necessary for both production and consumption, and the value of time depends on multiple factors and corrects economic agents' behaviour.

A little later, G. Becker's ideas were further developed in the works by DeSerpa, who proposed taking into account the minimum amount of time necessary to perform activities. The researcher identified three categories of time value:

1) the value of time as a resource, which meant the possibility of increasing the duration of the desirable activity by reducing the duration of the undesirable activity (calculated as the ratio of the marginal utility of time and the marginal utility of money);
2) the value of time as a consumer item, which considered the replacement of a certain activity with a job that provides household income;
3) the value of reducing the time to carry out a certain activity, which considers the possibility of reducing undesirable activities by comparing the minimum amount of time required to carry out a specific activity and the level of an individual's income. For example, if the travel time is reduced, the passenger has an additional opportunity to carry out other activities during the free time available.

From the point of view of the applied use of the provisions considered and in the context of the economic assessment of transport projects, we are mainly interested in the third category, which determines the attractiveness of transport services for users in the context of various factors.

2 Materials and methods

Among the previously mentioned works of G. Becker and DeSerpa, it is worth noting the following studies that formed the basis for this article [1-8].

The research in this paper is based on systematic, retrospective and comparative analysis with the view to studying the methodological apparatus of the economic category of time, as well as on general scientific methods of cognition such as abstraction, synthesis and analogy.

3 Results

3.1 The specifics of time as a special economic resource in the context of the analysis of transport projects

Despite the development of scientific and methodological approaches to considering time as a special economic resource, the transport industry is practically the only area where the benefits of releasing additional time are taken into account in economic calculations. For example, the UK government's industry-wide guide to the analysis and evaluation of investment projects "Green book" states that time resources are specific intangible values, which are supposed to be taken into account only for transport projects [9]. It is also worth noting that the global trend is to include the category of benefits from reducing travel time in the system of socioeconomic effects when evaluating innovative transport projects [10].

From the point of view of socioeconomic externalities that form during the implementation of the project and subsequent operation, the value of time is the central category of the procedure for investment appraisal of transport projects. Firstly, if passengers choose certain transport services, taking into account the cost of the trip, the time spent and the level of comfort, then it is necessary to consider these factors. Secondly, the change in the amount of time spent on trips serves as a catalyst for the formation of a wide range of socioeconomic effects, so the assessment of this indicator has an impact on the overall efficiency of transport projects.

Reducing travel time can be viewed positively for the following reasons. There is a potential increase in GDP if the saved time is used for work. In case saved time is used for personal purposes or rest, the positive result of saving time costs will be expressed in an increase in public welfare. Consequently, the benefits of reducing travel time extend not only to the passengers themselves who use public transport services, but also to society as a whole.

The 24-hour daily time limit means that the value of reducing travel time remains a key factor in assessing the benefits of transportation investments. The value of time costs is calculated by multiplying the time spent on the trip by the unit cost of this time, which varies depending on the type of a trip, travel conditions and a particular passenger's preferences. It seems clear that the most rational approach is to consider the concept of "the value of travel time" not as the actual cost of this time for the passenger, but as the significance of possible changes in the time spent on the trip, compared with the alternative use of this time.

As noted earlier, the provision on the value of reducing travel time is based on the rule of maximizing utility, according to which passengers strive to allocate their financial and time resources in such a way that each unit of resources brings equal marginal utility. The usefulness of funds directly depends on their available amount, and the usefulness of time depends on the amount of time available to the passenger. The passenger balances between the allocation of financial and time resources, taking into account the existing restrictions. Consequently, the value of a more limited resource will increase in relation to another.

It is worth pondering in more detail on the "resource" limitations of time, which fundamentally distinguish it from other economic resources. Firstly, the amount of available

time is strictly limited initially – there are 24 hours in a day, and this value is constant. However, for most people, part of the daily available time is spent on carrying out necessary activities that support their standard of living and existence, such as work or household chores. The remaining part of the daily time resource (excluding sleep) is free time that a person can spend on other activities that have subjectively high utility. It is the potential possibility of increasing the amount of free time that the value of reducing travel time is based on. Secondly, the time resource is not subject to accumulation, that is, it is distinguished by the impossibility of changing the level of consumption of this resource or creating some reserve of it for subsequent use. Accordingly, the use of time to carry out certain activities affects the daily fund of available time in the same way as non-use - in both cases, the available time resource will be reduced. Thirdly, time is used both for the production of goods and for their consumption, which causes unlimited demand.

To assess changes in time costs, the following indicators are used, the totality of which can be divided into two aggregated groups - characterizing the difference in subjective and objective perception of time.

Table 1. Indicator descriptions.

Subgroup	Indicator	Description
Objective	Travel time	The time allocated for the trip. The most common way of tracking time, measured in hours.
	Time spent on work trips	The value of time on work trips (paid time) depends on the level of income.
	Total transportation costs	The total indicator combining the amount of financial and time costs.
	«Effective speed»	In its economic sense, it is similar to the total transport costs, but the financial part of the costs is expressed by the amount of time it takes to earn money covering the cost of travel.
Subjective	Perceived time	Subjective perception of value on the way, reflecting the degree of satisfaction with the quality of the provision of transport services.
	Time spent on non-work trips	The value of time on non-work trips largely depends not on the level of income, but on the subjective assessment of time.

Travel time is measured objectively, and the indicator of perceived time is subjective, reflecting the level of satisfaction from the trip for an individual passenger. The assessment of the value of saved time resources is divided into the assessment of saved time resources of work trips and the assessment of saved time resources when travelling in free time. Work trips are understood exclusively as trips made during work, which excludes commuting to work. Passengers often realize the value of time resources; however, individual willingness to pay for time savings will vary depending on the income received, the goals and urgency of the trip, therefore, the value of the saved resources will be different.

Most trips are made by people in their free time (leisure trips and commuting), so saving non-working time accounts for a significant part of the benefits of transport investments. Paid time costs (time on work trips) are most often calculated on the basis of the cost of one working hour, and time costs during personal trips are calculated using perceived time. The effective speed indicator is used in a comparative analysis of the time costs that are required not only to make a trip, but also to earn money for a ticket. Consequently, even in the case of a reduction in travel time due to the use of a faster method of movement, the time costs calculated with this indicator may not change, since the time spent on earning a travel ticket will increase (the cost of travel on transport that provides faster movement is traditionally

higher). This indicator allows you to analyze transport changes, focusing only on the costs of time resource.

The value of reducing travel time in the simplest version can be expressed as a function of two variables – the marginal utility of time and the marginal utility of a particular passenger's money. As a rule, with the growth of the population's incomes, there is an increase in the value of reducing travel time and vice versa. In a more detailed form, the value of reducing travel time is determined by the passenger not only on the basis of his income, but also on the basis of the purpose of the trip, the quality of the service provided and the possibility of using time to meet certain needs. For example, an increase in demand for passenger transport services due to the implementation of a transport project that provides a reduction in travel time will be more significant if the value of reducing travel time is high. This will happen in cases when the passenger perceives it as lost time.

It is worth noting that with the increasing availability of information and communication technologies, the traditional way of considering travel time as completely wasted ceases to be relevant, since a passenger is able to carry out certain activities during the trip (work, rest, or sleep), which compensates for the loss of travel time and reduces the marginal usefulness of reducing travel time [11]. This provision is confirmed in practice – the results of social surveys [12] demonstrate that the possibility of using time productively is a significant factor for passengers when choosing a transport service. Another social study [13] has showed that the possibility of using time productively reduces the value of reducing travel time to about 20%. In other words, a longer trip with the possibility of using time productively is often more preferable than a short trip without such a possibility. That is, passengers appreciate better use of space and improved travel conditions in addition to speed.

When evaluating transport projects, an analytical approach is increasingly being used, which means that the cost-benefit analysis includes categories of effects arising not only from qualitative improvements associated with increased comfort or convenience of travel, but also takes into account the different value of the time spent on a trip, depending on its conditions.

From a passenger's point of view, time costs represent undesirable consequences of moving from one point to another. Consequently, the higher the level of satisfaction from the trip is, the less the passenger's willingness to pay for a reduction in travel time is. As a rule, the time costs of standing in a traffic jam in a crowded bus are perceived by passengers as more negative consequences than a trip in a comfortable seat of a personal car. For example, the value of reducing time during a relaxing walk through a picturesque area will be null, since a person enjoys the process and is not willing to pay more to shorten the walking time. However, the value of reducing the time when walking in unpleasant conditions (for example, along a busy highway) will be higher than when moving in a vehicle. Thus, the value of reducing time in most cases increases in conditions of discomfort, insecurity and congestion. This thesis is confirmed by social surveys, the results of which are analyzed in [14]. It is recommended to evaluate unwanted walking and waiting as 200-250% of the value of time spent in a vehicle. These clarifications also apply to the time required to access the vehicle and the time required to change vehicles.

It has also been established that passengers demonstrate a greater level of willingness to pay for the possibility of saving time in traffic congestion, or in the presence of a large crowd of people in waiting areas. A particularly high value of perceived time is observed in the case of unforeseen delays during events with a strict schedule, for example, during work trips. It can be argued that the heterogeneity of estimates of travel time, which depend on the quality of the trip, increases with a certain level of passenger solvency. It is worth paying attention to the following paradox: the most comfortable trips are characterized by a high value of reducing travel time, since the main consumers of this type of service are people with high income, and vice versa, passengers in crowded buses are often not willing to pay more for

saving time, since they have a limited amount of money.

Table 2 shows certain ratios of the value of travel time in relation to the purpose of the trip and the level of observed comfort, which have been obtained with the method of willingness to pay.

Table 2. Ratios of values of the time in relation to trip categories.

Trip category	Description	The value of time signifying willingness to pay for the reduction of time costs
A paid work trip	Travel of employees in paid jobs, for example, truck drivers.	150% of hourly wages
A trip for personal purposes, high value of time	Personal trips during which passengers experience discomfort, for example, driving in traffic.	50% of hourly wages for drivers, 35% for passengers
A trip for personal purposes, moderate value of time	A personal trip under comfortable conditions.	25% of hourly wages
Zero value of reducing travel time	A trip that a passenger enjoys and does not want to shorten the travel time.	-

The value of reducing travel time varies greatly and may vary even throughout one trip, depending on the conditions, since a passenger can enjoy the process of travelling, or vice versa, experience a number of inconveniences. The high value of time is most often observed in the following situations:

1. paid work trips;
2. urgent trips for personal purposes;
3. an uncomfortable trip;
4. unexpected costs;
5. long everyday trips duration of which exceeds 90 minutes.

Thus, travel time is a composite (in the sense of heterogeneity) element, the components of which differ in values (travel time using a trunk mode of transport, time spent on waiting for a vehicle, time of transition from one type of vehicle to another, etc.), which determines the need to evaluate each of the elements separately. This problem becomes especially relevant when evaluating transport projects involving the organization of multimodal passenger traffic.

3.2 Tools for the economic assessment of the benefits of reducing travel time

In modern worldwide practice, there are three main approaches that have formed the basis for a number of scientific and practical recommendations for evaluating transport projects: the cost-saving method, the Hensher equation and the method of willingness to pay. Each of these methods has distinctive features due to both the objectives of the analysis and a different set of factors taken into account.

From the point of view of applied use, the method of cost savings has become the most widespread, becoming a “classic” way of taking into account the benefits of reducing travel time. According to the cost-saving method, the value of reducing time on work trips is equal to the marginal product of labour, determined through the rate of gross wages and overhead costs. The cost-saving method implies that travel time is unproductive, and reducing the duration of the trip leads to an increase in productive time. The point of such consideration of the time factor value is that with the acceleration of transport communication, the time of passenger distraction from the sphere of material production is reduced. Accordingly, the

economic effect of reducing travel time reflects the potential for creating public product. Critics of this method argue that this assumption is appropriate only in the context of an economic system with perfect competition and full employment. In reality, economic systems are far from the state of perfect competition, so the release of time due to a reduction in time on work trips will not necessarily lead to additional work, which may distort the results of the assessment. It should be noted that the cost-saving method uses the market value of working time; it is difficult to implement in the case of evaluating the benefits of reducing time on non-work trips because free time has no market value. One of the possible options for assessing the benefits of reducing time on non-work trips with the cost-saving method is the use of lowering coefficients to the average salary level. Alternative methods for assessing the benefits of reduction in non-work trips are the Hensher equation and the method of willingness to pay.

The Hensher equation is a theoretical approach to determining the value of time spent on a work trip, which is rarely used in practice due to the difficulty of obtaining reliable estimates of the variables in the equation. This equation presents the value of reducing travel time by taking into account an employee's productivity during the trip, and consequently, the loss of productivity due to rest or fatigue. The calculation formula is presented below.

$$\mathrm{TSH} = [(1 - \mathrm{r} - \mathrm{pq})\mathrm{MPL} + \mathrm{MPF}] + [(1 - \mathrm{r})\mathrm{VW} + \mathrm{rVL}] \quad (1)$$

In which TSH – the value of reducing time on work trips (Heshner equation);
r – the part of the saved travel time intended for leisure;
p – the part of the saved travel time thanks to the work done during the trip;
q – relative performance during the trip;
MPL – marginal product of labour;
MPF – additional manufactured products due to reduced fatigue on the way (reduced travel time helps to reduce the level of an employee's fatigue, which has a positive effect on their productivity);
VW - the value of working time in relation to travel time for an employee at the workplace;
VL – the value of leisure time relative to travel time (coincides with the value of reducing travel time during personal trips) for an employee.

The first part of the equation (MPL+MPF) takes into account the value of benefits for an employer resulting from the release of saved travel time, which will later be used for work, and additional productivity by reducing fatigue levels on the road. It is worth noting that in the case of using travel time for work while reducing the duration of travel, the time spent on work during business trips will be reduced accordingly.

The second part of the equation (VW+VL) reflects the benefits for the employee, including the share of time saved and subsequently spent on leisure.

The main difficulty in the practical application of this equation is to assess the change in labour productivity resulting from a decrease in fatigue due to a reduction in travel time (a subjective factor) and to assess personal preferences for the distribution of saved time between income and work activity. As a result, a simplified version of the equation has been formulated:

$$\mathrm{TS} = (1 - \mathrm{r})\mathrm{MPL} + \mathrm{rVL} - \mathrm{pqMPL} \quad (2)$$

In which TS – the value of reducing time on work trips.

As it can be inferred from the equation, the reduced form differs in terms of the absence of an indicator of the value of time at the workplace in relation to the value of working time during the journey, since presumably there is no special difference for an employee between

the time spent at work and the time spent on the road during a business trip, therefore, the value of this indicator is null.

The reduced version consists of three components. In particular, (1-r) MPL reflects the value of the travel time used for work, the evaluation of which is based on the value of the marginal product of labour. rVL reflects the value of travel time used for rest, and pqMPL is an adjustment for the level of productivity during the journey.

Unlike the cost-saving method, the Hensher equation takes into account the fact that productivity on the road may not be lower than productivity at the workplace. Also, the cost-saving approach implies that all the time saved will be used for productive work activities, that is, the benefits are fully transferred to the employer. In turn, Hensher suggests that the saved time can go to an employee's rest.

The method of willingness to pay is based on the Kaldor-Hicks compensation test, which means that if in the course of a transition from state A to state B the winning side, at least, fully compensates for the losses of the losing side and nevertheless remains a winner compared to the initial situation, the changes are regarded as rational. Assessment of the benefits of reducing travel time using the method of willingness to pay is carried out using social surveys. The use of this method allows one to get the maximum level of financial costs that a passenger is willing to incur in order to reduce the time on the trip. The main advantage of this method is the ability to clarify the significance of various factors when choosing a transport service for a passenger. The method of willingness to pay, indicating the maximum level of financial costs that a passenger is willing to incur to reduce travel time, is mainly used to assess the benefits of reducing time on non-work trips. Among the disadvantages of this method, it is possible to single out the human factor that distorts the reliability of the results obtained (people often embellish reality in social surveys) and the specificity of the answers received, which are relevant for a certain region. Table 3 presents a comparative analysis of the methods considered.

Table 3. A comparative analysis of the methods for assessing the benefits of reducing travel time.

Method	Purpose of the analysis	Advantages	Disadvantages
Cost saving method	Change in GDP (GRP) due to the release of additional time	Relative ease of application and versatility of the results obtained	Almost does not take into account the benefits of reducing time on non-work trips; ignores the factors that cause a change in the value of reducing travel time.
Hensher equation	The change in GDP or in the level of welfare due to the release of additional time	Reflects the benefits for the employer and an employee on a work trip; takes into account labour productivity during the trip	Applied use is complicated by the presence of subjective factors that are difficult to account.
The method of willingness to pay	Changing the usefulness of a transport service for a passenger in relation to the conditions of travel	Makes it possible to take into account the factors relevant to a passenger when choosing transport services; assesses the norm of free time preferred	The results of social surveys do not always correspond to the real behavioral pattern of the passenger; the results obtained are not universal and may require clarification for further use.

3 Conclusions

A retrospective analysis of the category of time has revealed a methodological transition from considering time as a passive parameter to regarding it as an active variable of economic

models, which contributed to the "materialization" of time: time plays the role of a fully-fledged economic resource necessary for both production and consumption.

The paper confirms the multifactorial dependence of the value of time, which determines a passenger's willingness to pay for a reduction in travel time, not only on the level of the passenger's income, but also on the purpose of the trip, travel conditions, and preferred activity, and specifies ways to estimate time as part of the total transportation costs. There has been justified the necessity of assessing time changes in the context of the total transport costs borne by passengers, taking into account the identified factors that stipulate different values of the benefit of time reduction.

It is established that the socioeconomic effect of reducing the time spent on a trip consists not only in the volume of additional product emerging in case of using the released time to do work, but also in improving public welfare due to the growth of human capital based on an increase in the amount of free time.

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