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PROBLEMS OF ECONOMIC ASSESSEMENT OF SPEED IN TRANSPORT AND LOGISTICAL SYSTEMS IN THE NEW TECHNOLOGICAL PARADIGM

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The article suggests a methodological approach to assessment of speed costs of transport systems at the new technological paradigm (*The Fourth Industrial Revolution*).

Objective: The purpose of the work is to study economic effects of transport and logistical systems (TLS) performance as the infrastructure of high speeds economics.

Methods. Deep analysis of railway infrastructure as a subsystem has been given, which has marked competitive advantages and ensures inclusion of the transport system in the new technological paradigm.

The basic parameters of influence of new technological paradigm on transport systems, namely, dominance of global network production and consumption, supply chain management and added value creation through integration of products and services.

The methodology of the study is based upon quantum description of the economics as a combination of the initial indivisible (quantum) economic structures (model or image), actions and relations between them (service business model), processes (predictive maintenance, state tracking), economic interaction between economic action objects (joint use of resources, instant response) in the space and time.

The authors have introduced the notion of high speed economics as a measure of the society's taking innovations, which changes all national and global markets, access to them, and interbranch value chains creation. Time management, high speeds are the key competitive advantages of the scheme: "order – fulfillment of the order (service business model)".

Results. The methods for assessment of speed of TLS, new nomenclature, method of high speed caused effects assessment have been developed. The algorithm of decision making about value of high speeds for transport services consumers in the new technological paradigm has been justified.

On the basis of the analysis of three different distance transformation: length, connecting two objects (expressed in length units), costs and time (speed) for covering distance, − practical application of vector coefficient of the intensity of motion processes as the unit of measurement of any motion has been justified. As the assessment of time and space efficiency of TLS projects' development, the product of the weight of the goods transported and vector coefficient of motion intensity is used.

Speed assessment, time value, high speed economics, technological paradigm, quantum economics, motion intensity.

Introduction

Transformation of transport systems is determined by new technological paradigm. The history of mankind saw every other transmission to new paradigm formed its corresponding transport system. Todays, it is written much about innovative transport systems, forgetting that the top of the innovation pyramid is covered by the essence of the innovative product commercialisation – transport service in this case. It is the transport service with its properties, production and consumption processes that acquire new different essence in the near future economics.

In recent years, the issue of what should become the locomotive of innovative renewal of transport systems has been actively discussed: a new mixed transport service, production of new types of rolling stock, or transportation as an industry as a whole; or a sphere of activity linking production, exchange and consumption. How to evaluate the effect of high-speed breakthrough technologies in transport systems?

From our viewpoint, the issues should be described from the view of transition of the society to new technological paradigm, namely the industry 4.0. This paradigm forms the system of economic relations, the central part of which is the category of time[1]. The process of waiting for new goods and services is changing significantly, and under the conditions of individual preferences at any time and in any place. The economy is striving for high production and transportation speeds. In this respect, projects for the development of high-speed transport systems acquire other properties and, therefore, require fundamental changes in the methodology for assessing their values.

The purpose of this study is to economically describe the assessment of speed in transport systems of new technological paradigm. In this connection, two objects of research arise: transport systems and new economy, the essence of which is high speed economics, formed by new technological paradigm. They are bound so closely that considering them separately would change the essence of speed assessment. This is bound with the following circumstances.

1) The world is entering the new high-speed category. Infrastructure branches of the economy and, in the first place, transport and logistical systems will boom economically. The role of transport as an intermediary will decrease drastically in favour of consumer properties of goods and technological rent. The so-called "sharing" and "circular" economies are being widely discussed already [1]. We have previously introduced and described the notion of *high-speed economics* as a way of doing business, whereby the main effect is detected by estimating the cost of time as the main, non-renewable resource [2].

[1] See, for example, the time saving law defined by David Ricardo and introduced by Karl Marx (Marx K., Engels F. Work in 30 vol. 1961. T. 24. P. 648).

2) In the modern history, the focus on efficient transport systems has become a cornerstone of the development of the infrastructure of competitive commodity markets. At the same time, the current transport systems have practically exhausted the growth reserves in the present technological paradigm. The transition to a more advanced technological structure requires an appropriate transport system.

3) In transport systems, the subsystem of railway transportation has marked competitive advantages, thus ensuring the first place inclusion in the new technological paradigm. These are, first of all, possibility of mass freight and passengers transportation; high capacity; non-stop transportation irrespective of climate conditions; higher speed potential, including that in transport corridors; fast development of high-speed transport, including freight one, for example of the bases of magnetic suspension. The most difficult point in railway transportation is its infrastructure: high costs and long payback periods of its modernisation projects. However, on the other side, it is railway infrastructure that is exposed to new technologies influence. For example, the Hyperloop project with its 1200 km/h passenger transportation or magnetic levitation with its up to 1000 km/h container transportation.

These circumstances are the defining points of the emergence of high-speed economics on the basis of high-speed infrastructure of transport systems in the formation of the new technological paradigm.

Traditionally the assessment of efficiency of HSR projects is based upon or a combination of several methods, such as: a method of difference of efficient transport expenditures and a method of net present value assessment. Other effects (social, ecological, etc.) are considered either indirect methods on the bases of expert assessment, or a direct account. From our point of view, this approach is applicable only to technical modernisation projects and reconstruction of transport systems. In the case of transport systems of a new technological paradigm or high-speed economy, the application of standard economic efficiency assessment is incorrect.

In this study, the basic speed assessment problems are bound with determination of transport and logistical systems as infrastructure of high-speed economics, namely taking into account a set of effects arising in the production and consumption of high-speed transportation services, as well as the multiplier effect.

The set of study methods have been based upon the quantum description of economics as a combination of initial and indivisible (quantum) economic structures (model and image), actions and relations between them (service business model), processes (predictive maintenance, state tracking), economic interaction between economic action objects (joint use of resources, instant response) in the space and time [3–5].

Transport and logistical systems as a research object

There are different notions of transport and logistical systems (TLS). Traditionally, they mean a combination of consumers and service producers, as well as the management systems used, vehicles, communication routes, structures and other property. In more extended definitions, the transport and logistical system is defined as a combination of objects and subjects of the transport and logistical infrastructure, together with material, financial and information flows between them, performing the functions of transportation, storage, distribution of goods, as well as information and legal support for commodity flows.

In any case, for a proper functioning of the TLS, the relative infrastructure is needed. The processes of transportation, storage, distribution of goods, as well as information flows accompanying them, require certain technical means. These means make the infrastructure of logistics, and their relation make the logistical system. The infrastructure should ensure accurate and uninterrupted performance of all logistical functions. The infrastructure of transport logistics encompasses:

- transport routes of all types of transport, including pipelines, as well as transport hubs, namely sea hubs, river hubs and airports, container terminals, railway transshipping and shunting stations, combined transport terminals;
- buildings and other facilities ensuring storage with its technical equipment,, enabling manipulation of freight and realisation of basic functions, for example, packaging, and loading and unloading fronts, loading ramps;
- elements of the key logistics infrastructure, such as distribution centres, logistics service centres, transport and storage facilities;
- equipment and means of information processing and transmission together with relative software.

In accordance with the EU classification, transport and logistical system has the following segments:

- freight transportation and forwarding services;
- complex logistical services including storage and distribution of goods;
- management logistics, including optimisation of logistical business processes.

From the perspective of our study, it is necessary to describe the TLS as an infrastructure element of a high-speed economy. The economy of TLS generates added value at the expense of the services of compiling optimal routes for the delivery of goods, ensuring the full load of transport means, controlling the passage of goods at all stages of the supply chain, and so on.

This service spectrum should be described in the language of a consumer namely easy to understand and sought after by them, as well as have a marked value. Every service has clearly stipulated parameters, guaranteed quality and a known cost. The service may have several levels, each of which being a set of own service parameters value. A client chooses the contents and the level of the needed service. The relations between the client and the supplier are fixed by the SLA (Service Level Agreement).

The new technological paradigm predisposes the management of supply chains and the creation of value added through the integration of products and services. The TLS should take into account the dominance of global network production and consumption.

Now, the most efficient TLS is the Third Party Logistics, developed at the expense of outsourcing of a part of a company's functions in organisation and support of dealership network and creation of inbound logistics and outbound logistics, as well as reverse logistics. In accordance with the classification approved, 3PL is based upon on warehousing and processing services, organisation of transportation, and management of goods flow during the transportation. According to leading 3PL operators, in the last five years the contract logistics market volume has increased by an average of 8 % per year and amounts to 55 % of the volume of the global transport and logistics market.

However, the speed of providing 3PL services cannot meet the demand of high-speed economics, primarily due to constraining transport infrastructure and fragmented digitisation of logistics processes. The meeting of the demand might be achieved at the expense of logistics level 5PL (Fifth Party Logistics) or "Internet Logistics", consisting in management of all elements of the chain by means of global information technologies. At the same time, the realisation of this level of transport and logistics service should be ensured by relative high-speed infrastructure.

High-speed economics

The speed in the new economic paradigm generates a new economic entity – high-speed economics. Actually, high-speed economics is an economy where the future time equals the present time and is equal to the past time. It means, in the evaluation of time, the forecast, the plan, the fact coincide with the forecast analysis being the main tool for its analysis.

High-speed economics modifies all global and national markets, the system of access to them, interbranch value chains and, accordingly, the competition goes beyond existing markets towards the struggle for the formation of new ones. Goods and technology competition will cease to be relevant – the main struggle is already going for time management systems, or high speeds. Like any type of economy, – the economy of high speeds changes not only the supply sphere, but also consumption one. And this process cannot be described as: "demand creates supply" or "supply forms demand", i. e. the basic postulate forming today's economic policy.

The main indicator of the development of a high-speed economy is the measure of innovations accepted by the society, not only technological, but also managerial, economic, social. It should be noted that with each new technological paradigm, the speed of acceptance of innovations is several times faster. So, if the first technical revolution - mechanisation (using water and steam for production purposes) lasted more than a hundred years, the current one – automation (use of computers for the automation of production) since the beginning of the 2000s has been almost completely mastered by now.

At the heart of the new technological paradigm the so-called Industrialization 4.0 lies. It is the Internet, the concept of the computer network, industrial production and sophisticated machines integrated with intelligent systems.

The technological progress (its involvement in the change of future will be measured 79 % of the entire influence) will influence the production chain, namely, cancellation of the traditional system "production-realisation" being replaced by "order-fulfillment service (service business-model)". And the changing consumption model – "cross-branch automation, instant order, consumption service" will be replaced by "production supply chain".

It is advisable to consider transformation of industry to some other, different production organisation and emergence of "smart" product or service. Transition from mass production to customer-ordered production and from integrated plant concentration on competitive advantages will significantly change the very service of transportation: small lots under the order with delivery «just in time» for long distances. The emergence and mass distribution of «smart» product (sensors, programmable matter, etc.) will lead to significant increase in its software costs and to the requirement to minimise the transport component at the final price of consumption.

The high-speed economy, built on the "combination" of future and present, will change the value of "ownership" to "use", since the main thing for the consumer is the realisation of individual needs and the most important problem will be a compromise of public and individual needs.

A new organisational model of business is in the process of formation. Focus on specific consumer and the full use of information as a driving resource, consideration of specific features of a particular consumer in a particular place and use of the technologies of digital transformations of real business processes in every possible way, reconstruct the entire scheme of relationships in the economy and society. A new tree of transformation goals is being formed: realisation probability, maturity of possibilities, their completeness of digitisation and consideration of risks during implementation.

High-speed economy should strive to ensure zero time of waiting for new products and services in the conditions of individual preferences anywhere and anytime. The model of this economy should "inevitably welcome" constant improvement. Since the client is an essentially vital part of a successful strategy, their feedback develops tactics which strives to improve quality and speed of service. On the other hand, information of this feedback enables making more precise analytical forecasts. And at this stage, the plan and forecast coincide in time. This significantly changes the image of transport and logistical systems.

Methods of speed assessment

Methods of speed assessment of TLS, corresponding to the economy of high speeds, requires development of the set of notions, scientific and methodological base of evaluation of their creation and implementation effects. They also require justified algorithm of decision making as to their value for consumers of transport services in the new economic paradigm.

The above described alteration of the business model of transportation will lead to the transformation of transport and logistics systems into integrated logistical support of production. This means that methodologically, assessment of speed should be related to the contract of the product's life cycle (service). Long-term service relations should rest on the life-cycle contract of any high-speed project, which reflects the economically justified purchase of the product and its support services as an integrated package of standardised factors that make up the service. Under the standardised indicators of the service, we mean its operational readiness.

It is the standardisation (“normality”) of the factors of a service (or product) that makes it possible to “digitize” the economic processes of new transport systems, their market behaviour, competitive strategies, which leads to understanding of the cost of speed.

As it is known, in assessment of the efficiency of the digital economy, a unit of value as the indicator is used. It is connected, first of all, with considerably lesser labour intensity of all business processes, as well as costs of public, intellectual, political processes. The greatest use in assessing the level of development of the digital economy was acquired by BCG e-Intensity[1], calculated as the weighted average of three subindexes: infrastructure development, online expenditures, user activity. We can use these indicators in determining the value of time in the TLS of a high-speed economy or a new economic paradigm.

This study suggest TLS speed assessment in the new economic paradigm based upon the quantum description of economics as:

- a combination of initial indivisible (quantum) economic structures (model and image);
- actions and relations between economic structures (service business model);
- processes (forecast service, state control);

[1] BCG e-Intensity. https://www.bcgperspectives.com/content/interactive/telecommunications_media_entertainment_bcg_e_intensity_index.

- economic interaction between economic action objects (joint exploitation of resources, instant reaction) in time and space.

Time, being an economic category, transfers the emphasis of value from the initial price of the acquired product or service to the total cost of ownership. Possession of an efficient transportation service is ensured when the long-term average cost curve of the TLS acquires a downward character. In the case of railway transport systems, it is possible when high-speed traffic projects confirm the effect of growth explained by increase of network density and speed of traffic. Operational unit costs decrease as the productivity of the railway line increases, because the fixed cost of railway operation provision is distributed to an increasing number of units of transport. To detect the speed effect of the railway network, a high degree of infrastructure operation is required with an increase in the speed of transportation: the higher the operation rate is, the better is the infrastructure economy, the greater the profitability can be provided to its owner and user [6].

Time as economically valued unit may be detected using two basic indicators: identical effect (the required quantity and quality of the transport service) with minimisation of time spent for its obtaining or positively increasing efficiency in the long-term payback projects. On the transport, positive value of these indicators can be achieved: by means of implementation of new technologies, detecting the effect in increase of capacity and speed of a transport system; by means of real growth of marginal incomes of freight senders and value growth among the passengers. The economic justification of new railway technologies had a term "social speed" introduced, which allows defining the moments of time, transition points of another stage of development of the line by means of implementation of transport technologies and products [7].

Based on the three different transformations of the distance: the length connecting two objects (expressed in units of length), the costs for covering the distance and the time to cover it (speed), there is a relationship between them and a substitution phenomenon.

In accordance with this statement, we suggest the following methodological approaches to the description of speed.

First, it should be specially emphasised that measure of the cost of transportation is not only labour and capital expenditures, but also the expenditure of time, since each change of the spatial position of matter requires motion, and every motion happens in time. Thus, the process of covering the spatial distance between the initial and final points is a chain of actions and relations between them (the service business model), which can be transformed into a temporary concept or speed (Dt).

Secondly, the motion distance is an interval, dividing transport and freight traffic emergence places. This interval (distance) may be viewed differently. In the first place, it is a combination of initial indivisible (quantum) economic structures or a spatial distance expressed in length (kilometres, miles, etc) (Dl).

Thirdly, as it was previously pointed out, shortening distance technologies match the technological paradigm, and in our case they are researched thorough assessment of the state of TLS as the infrastructure of high-speed economics. It is TLS that generate expenditures related to covering distances. In other words, economic expenditures on covering spatial interval between two points reflect economic interaction between objects of economic action (joint exploitation of resources, instant reaction) and in their turn, are reflected on the cost of transport production, forming economic distance (Dk). But different distances have a different need for covering them, associated with the effect of gravity inherent in every particular stage of development of society. If we rely on the principles of quantum mechanics, then the velocity operator depends on the momentum operator divided by the mass of the transport. This need can be described by the concept of direction.

In terms of economics, direction means that for covering the distance, the consumer is willing to pay the fee that meets the requirements for its benefit. The most correct value can be reflected by the marginal profit. But in this application this indicator should be specified. First of all, it is worth saying that the word “profit” in the Russian-speaking economy means “revenue minus costs”. The term “marginal revenue” (in English) is used in two ways: “marginal profit” is the additional income received from the sale of an additional unit of goods and the “income” received from sales after recovering variable costs. In the latter sense, marginal revenue is the source of profit formation and coverage of fixed costs.

Despite the fact that such calculation of marginal revenue does not show the completeness of its dependence on fixed costs, variable costs and prices, this dependence is easy to detect with the known interpretation of the formula, which in our case, with regard to transport products, allows us to distinguish the influence of time and space factors in it.

If we assume that the velocity is the distance and direction transformation function, then

$$Dt = f\sum\frac{\infty}{n=1}(Dl, Dk), \text{ or } D_t = m\frac{Dl}{Dk},$$

where m – coefficient, which reflects functional dependence at different levels of TLS technology.

Accordingly, basic problems of consideration of time factor in the cost of railway transportation may be assessed with by means growth of marginal revenue

- from shortening transit time (high-speed infrastructure);
- growth of marginal revenue from the development of the infrastructure of new income-generating directions;

- growth of marginal revenue from the growth of speed at the maximum distance of transportation.

The same way can be used when assessing the costs of any product or service ownership.

Considering high-speed transport system, we come to a new indicator – added value in the value of time, with the added value generated by distance in kilometres and gravitational value of direction. This means that in the assessment of time, the vector coefficient of the intensity of motion processes can be used as the unit of measurement of any motion, and as assessment of the temporal and spatial efficiency of projects for the development of transport and logistical systems − the product of the mass of the goods being transported by the vector coefficient of motion intensity.

Thus, the speed, direction and distance can form an indicator of the assessment of motion time in monetary terms or the cost of 1 unit of the transportation service by a high-speed transport and logistics system.

Further modelling and digitisation of these parameters are the basis of the approach to assessment of the economic efficiency of speed in the infrastructure projects of high-speed economics.

Discussion (history of the issue)

The first studies describing time as the economic category sprang up in 1960s. The most complete study was made by I. Tarskii [8]. However, the active discussion about the value of tine and problems of speed assessment of transport systems have been conducted only lately. The beginning of the discussion is connected with the society's understanding of demand in high-speed transport systems, namely, HSR influence on transformation of national and regional economies, elimination of regional differences and activation of economic growth [9].

Part of the studies is connected with the sphere of strategic analysis of HSR both for the environment and for sustainable growth of regions. In particular, high-speed communications development strategies in the EU have been explored on the basis of three high-speed railways with different capacities: HS2 in the UK, RFAV in Portugal and the European railway line Kaunas Baltica 2. The authors analyse the criteria for necessary and strategically justified decisions in the adoption of the HSR projects [10].

Some authors discuss the problems of competitive models of high-speed railway transportation organisations and the influence of the frequency and speed of traffic on the assessment of the cost of a high-speed railway system [11].

The most part of the discussion is related to the value of time. In particular, the study of mixed HSR transportations, namely, the integration of railway and air transports is investigated in the source [12]. The authors assess the influence of reduce of transportation time on the profits of operators and the growth of the value of this service for passengers. In the same paper, the possibility of growing cost of integration on the basis of transport mean exchange time decrease.

In the development of the problem of the integration of high-speed modes of transport (air and railway transports), the efficiency of their intermodality and internal competition is discussed. A number of authors analyse the dependence of the demand function on transportation from the population's incomes, the competitive costs of air transport and the prices for alternative railway transportation. Original researches of the cross elasticity of high-speed lines of various types of transport are conducted, and the competitiveness of high-speed railways is confirmed [13].

The problems of the methodology for assessment of macroeconomic risks of reducing the efficiency of high-speed lines and general methodological approaches to assessment of the efficiency of high-speed traffic projects in various economic conditions, based in particular on NPV and IRR indicators and various values of the discount rate are considered in [14].

A critic analysis of the economic assessment of the effects of high-speed lines based on the Swedish high-speed railway infrastructure project and the role of this assessment in the project decision-making process is given in [15]. The author believes that the existing methods for evaluating such projects are not sufficient, they are methodologically incompatible with understanding real effects and rather serve as a justification for the application for a project or for the intent to create high-speed lines. We totally share this point of view.

Some of the authors point out that in the methods of speed assessment the high-speed lines spatial efficiency effects should be considered. In particular, this kind of research of the basis of China's HSR is seen in the work of Sh. Jia, Ch. Zhou, Ch. Qin [4]. This study constructs a market area evolution model from the perspective of economic subject and location matching under the hypothesis of non-homogeneous space. It is proved that transportation development can reduce transport costs, which is closely related to location factor endowments the economic impact of high-speed rail were studied by DID and PSM-DID methods. The results show that China's high-speed rail construction has a positive effect on economic growth and will become an important force in reshaping the organization of China's spatial economy.

Procedures of HSR spatial influence are researched by a number of authors, in particular, on the example of agglomerations. The authors maintain that, procedures for assessing the spatial impacts of HSR must therefore follow a twofold approach which addresses issues of both efficiency and equity. This analysis can be made by jointly assessing both the magnitude and distribution of the accessibility improvements deriving from a HSR project. This paper describes an assessment methodology for HSR projects which follows this twofold approach. The procedure uses spatial impact analysis techniques and is based on the computation of accessibility indicators, supported by a Geographical Information System (GIS) [16].

The assessment of spatial efficiency of transport logistics on the regional scale has been considered in the work of P. Srisawat, N. Kronprasert, K. Arunotayanun [17]. This study used the GIS technology to analyses the Multi-Criteria Decision-Making model and visualise the spatial data. The proposed spatial decision-making tool embedded in a GIS platform can be a powerful tool to support decision made in case of highly complex spatial data. Such data related to efficiency evaluation can be visualised for the potential, advantages, and disadvantages of each area and can be used for strategic planning, enhancing logistics efficiency in regional areas.

Fort the purposes of this study, the methodological work in the field of quantum mechanics is significant. In particular, Maslov's work reflects a discussion on the psychological, sociological and statistical issues of the economy in their connection with the new idempotent, or "tropical" arithmetic. The mathematical substantiation and refinement of empirical statistical regularities in the economy, which is important for the methodology of describing the economy of high speeds, is given [18]. In L. Braev's work, the concept of a non-quantum quantum economy is proposed: the deduction of prices and cycles from technologically necessary proportions and lags of consumption, production, money exchange and their modernisation [5].

Conclusion

Thus, transition of the society to new technological paradigm, the Industry 4.0, forms a new system of economic relationships, the central point of which is the category of time. The system of waiting for new goods and services is changing significantly, and in the conditions of individual preferences at any time and in any place. The economy is striving for high production and transportation speeds. A new essence appears - the economy of high speeds.

This research of tendencies of transformation of transport and logistical systems into a new future technological paradigm allowed drawing the following conclusions:

1) the existing methodology of assessment of the efficiency of projects of high-speed transport and logistics systems does not take into account the value of time;

2) the formation of a new methodological approach to the assessment of high-speed projects requires rethinking the category of time and its transformation into speed in a new technological paradigm;

3) time as economically valued unit may be detected using two basic indicators: identical effect (the required quantity and quality of the transport service) with minimisation of time spent for its production and positive rising efficiency in the projects owing to increase in the profitability of transport service consumers on stage of operation.

We should expect that alteration of the business model of transportation will lead to the transformation of the TLS into integrated logistical support of production. This means that the methodological assessment of speed should be related to the contract of the product's life cycle (service). Long-term service relations will have to be based on the life-cycle contract of any high-speed project, which reflects the economically justified purchase of the product and its support services as an integrated package of standardised indicators that make up the service.

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