

# SYSTEMS ANALYSIS OF TRANSPORT PERFORMANCE AND DEVELOPMENT

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## Summary

System analysis of transport includes studying it as a complex system that has got numerous and various connections both with external environment and its subsystems and elements. In this paper as external environment in relation to transport system economy on the whole is considered. Description of the world transport system's scale, structure and tendencies of development is given in Section 2. In Section 3 one of the most important aspects of transport system's external connections is studied - its influence on impacts manifested themselves in other industries and various spheres of the population's vital activity. Such effects are called transport externalities. They can

have considerable influence on income and expenditures of non-transport enterprises and terms of populations vital activity, but they aren't shown in income and expenditures of transport enterprises.

Peculiarities of labour and capital interaction in transport enterprises influence greatly their institutional forms. In Section 4 spheres of effective functioning of transport enterprises based on various forms of property are analyzed. It is shown that along with other forms of property, in certain conditions existence of transport enterprises with state- and self-supporting form of property is reasonable and their effective functioning is possible.

Availability of important and wide segments of transportation market being a sphere of natural monopoly of big and very big (up to national and transnational) transporters, as well as special role of transport in guarding strategic national interests result in the necessity to form and actively pursue national transport policy. Its most important elements are state regulating the relations between transporters and consumers of their services, as well as investment state policy in relation to transport. These questions are regarded in Section 5.

Detailed analysis of quantitative characteristics of interconnections between transport and other sections of economy is fulfilled using a special modification of input-output balance mathematical model. With its help methods are elaborated of studying transport tariffs changes influencing the price system in economy on the whole, as well as shaping financial results in all the sectors of economy, their investment possibilities and, finally, possible rates of growth both of economy on the whole and its separate sectors, including transport itself.

Along with it, transport tariffs influence the system of consumer prices is taken into account both through transportation mark-up to producer price and those prices themselves. The latter depend on producer costs and they, in their turn, on prices at which goods and services related to producers' intermediate consumption, i.e. prices including transportation mark-up, too. Corresponding mathematical model is expounded quite thoroughly in Section 6.

Methods of optimization of transport internal development are regarded at the example of solving a problem of optimization of transport network development. This problem is considered in two formulations - for the network separate element if the growth of its infilling is only determined by newly emerged transportations, in fulfillment of which other network elements cannot participate; and for the network on the whole, when development of its separate elements might lead to re-distribution of total volume of transportations between them. These questions are considered in Section 7.

In Section 8 mathematical optimization model of interaction and intercoordinated development of transport and warehouses under such conditions when presenting freights for transportation has got considerable seasonal variations. It is shown that under those conditions necessary reserves of transportation capacity and warehouses capacity are partially interchangeable. Usage of the abovementioned model makes it possible to determine optimal combination of these two kinds of reserves.

## 1. Introduction

Industry “Transport” includes:

1. Automobile transport
2. Highway economy
3. Railway transport
4. Sea transport
5. Internal water transport (river, lake)
6. Air transport
7. Tram transport
8. Trolleybus transport
9. Undergrounds
10. Gas pipe-lines
11. Oil pipe-lines
12. Petroleum product pipe-lines

Tram and trolleybus transport and undergrounds perform specific functions of urban passenger transportation, their connections with other elements of urban economy are closer than with transport, functioning out of town, therefore it is expedient to consider them as an element of urban economy. In this paper such kinds of transport are not considered. Town-service buses should be considered as an element of urban transport and urban economy, nevertheless, in the majority of countries they are accounted as a part of automobile transport.

Devices, meant for transportation of people and freight that are fulfilled within enterprises as part of technological process of production (well hoists, mine transport, conveyers, truck loaders and so on) do not relate to “Transport”, their functioning is accounted in corresponding kinds of production.

All kinds of transport except for pipe-lines include transport facilities and infrastructure.

Transport facilities - mobile devices with which passengers and freight are transported. These are automobiles, railway cars and locomotives, sea, river, air vessels meant for transportation of passengers and freight. Automobiles, cars, vessels of special purpose - i.e. lift cranes on wheels, automobiles, cars, vessels in which bodies and cabins various industrial assemblies are installed (for example, drilling equipment), laboratories, experimental stations and so on - do not relate to transport facilities.

Transport infrastructure - a package of transport devices that guarantee a possibility of usage of transport facilities. The main element of transport infrastructure is transport roads - motor roads; railways together with energy supplying devices, systems of control over switch-points and signals; rivers with vessels equipment, canals and so on. Railway stations, warehouses of common usage situated along the railway lines; sea-, river- and air-ports together with all their equipment intended to serve passengers, freight and transport facilities. Functionally, tractors (for pulling train of trailers), shunting and even train locomotives, port tugs, bunkers and other serving fleet should be related to transport infrastructure too, but they are traditionally regarded as transport

facilities.

In pipe-line transport freight transportation is performed without using transport facilities, so all its devices relate to transport infrastructure.

In all types of transport, except for railroads, infrastructure and transport facilities are divided organizationally. In a majority of countries infrastructure and transport facilities in railway transport are united together within a common enterprise, however, in a number of countries the process of their organizational demarcation (partial or even full) recently began to develop actively.

Transport is a complex system with a developed net hierarchical organization, a great number of local and regional centers governing its technological and economic activity. Notwithstanding a high level of technological processes automation, including processes of governing transport technique and people's activity, a "human factor" influences decisively safety and effectiveness of transport functioning.

Systems analysis of transport includes complex inter-disciplinary study of transport system performance on the whole and its individual systems separately, too, as well as transport interaction and interactions with the external social and economic environment.

## 2. Place and Role of Transport in National Economy

The scale and structure of national and global transport systems are determined by the volume and structure of demand for their services, ability and readiness of national and transnational investors to finance development and modernization of transport systems, directions and rates of growth in the fields, connected with material and technical transport base, and possibility of transport enterprises to put innovations into production. Volume of demand for transport services and their quality requirements are determined by territorial distribution of production, its industrial structure, specialization and cooperation, directions and intensity of world economic relations, as well as density of population, its concentration in settlements with different number of people, typical distances between them, standards and mode of living of people. Transport, in its turn, performing freight and passenger transportations between enterprises, regions and countries actively influence the scale and the structure of national economy of every country, its place in a system of world economic relations, as well as population's living standards and mode of living.

The main parameters of world transport system and their dynamics are shown in Tables 1, 2 and 3.

Types of transport	Years			
	1950	1970	1980	1990
Railways	1320	1340	1248	1210
including electrified	60	125	164	193
Motor roads	15540	19700	22300	23600
including				

with hard coating	7645	12150		20000
out of them improved	2920	5860	9210	11700
Navigable rivers and canal	560	525	16000	544
Oil Pipeline	175	395	520	600
Gas Main Pipeline	186	545	760	900
Air ways	3300	5510	6900	7900

Table 1: World Transport System. Dynamics of Network ( $10^3$ .km)

Types of transport	Years			
	1950	1970	1980	1990
transport	6.9	28.9	47.6	45.7
All the types, bln. t/km				
in % to total volume:				
railway	30.8	18.9	14.5	16.1
motor car	7.5	8.0	6.9	8.3
internal water	5.6	3.0	2.5	2.7
sea	51.9	62.7	67.5	62.1
oil pipe-lines and oil-products pipe-lines	3.1	5.0	6.0	7.2
gas main	1.1	2.3	2.5	3.6
air	0.1	0.1	0.1	0.1

Table 2: World Transport System. Volume and Structure of Freight Turnover

Types of transport	Years			
	1950	1970	1980	1990
transport	2.5	8.0	14.2	16.1
all the types, bln. Pass/km				
in % to total volume:				
railway	25.6	15.2	11.8	11.2
motor car	71.4	77.2	79.0	79.0
Including bus	14.6	16.7	19.0	19.8
car	56.8	60.5	60.0	60.1
internal water	0.6	0.5	0.4	0.4
sea	0.8	0.3	0.3	0.3
air	1.2	6.7	8.5	8.2

Table 3: World Transport System. Volume and Structure of Passenger Turnover

During the last several decades transport intensity of the world economy per a unit of

gross national product calculated in constant prices remained approximately the same. Specific volume of freight turnover grew by 30-35 per cent per a ton of product produced, and per capita 3,5-4 times. Approximately in this correlation specific quantity of passenger turnover per capita increased (the so called "population mobility").

Total length of transport network by modes of transport during that period remains stable under considerable qualitative change of the network: the length of electrified railways, motor roads with perfected coating, pipe-lines of large diameter are growing. Both in the world freight turnover and passenger turnover one type of transport is marked out distinctly, the share of which in the total volume of operations keeps growing - that is sea transport in freight turnover (growth from 52% up to 63%) and motor car transport for individual usage (from 56% up to 60%).

Transport adapts to the latest changes and tendencies in the world economy and world development and for new requirements of customers that is caused, in particular, by sharp rising a degree of industrial products processing and change in international relations. This leads to enhancing requirements to speed and timeliness of delivery, to freight safety, to reliability of stable transport lines work.

As freight mass "is being improved" factors of transportations quality are becoming increasingly important and a factor of transport current cost steps back. The most striking manifestation of this tendency is formation of the world container system. World container turnover amounts to 70 million units per year, about 40 per cent of the whole volume of general freight is transported in them. Recently development of the world container system caused formation of transcontinental container "bridges", i.e. a combination of regular sea lines with express high-speed railway trains and road trains. The most important examples of such "bridges" are Trans-Siberian (Japan - West Europe), Trans-American, West Europe - Near East and Middle East.

In the sphere of passenger transportation a tendency of population mobility growth and enhancing requirements to comfort of trips that could be provided at public transport as well, an aspiration for trips "privatization", that is for absence of tough train schedule, chance fellow - travelers and free choice of route of movement, is getting stronger. These requirements in the aggregate determine stable growth of motor car individual transport ratio to the total volume of passengers transportations.

It is important to note, however, that this mode of transport is, at the same time, the most power consuming one, as well as the most "dirty" from ecological point of view: therefore a tendency of its share's growth has got natural restrictions of systems character. A high share of individual motor car transport in the world passenger turnover is achieved nowadays at the expense of developed countries against the background of general low population mobility in developing countries. As the latter grows the difficulties, connected with high power intensity and ecological impact on the environment by individual motor car in transport will also increase. If mass ecologically clean individual motor car transport could be created (for instance, electric motor cars), it would lose to a certain extent the acuteness of ecological problems connected with such transport, but along with it a problem of wasteful use of energy resources would grow because the efficiency of providing with energy for such transport facilities is

much lower than that of motor cars.

For transport the following peculiarities that are typical should be taken into account under analyzing and elaborating strategies of managing of its performance and development:

- functional unity of transport subsystems, their partial interchangeability;
- inseparability of processes of consuming and producing products, impossibility of accumulation and storage;
- importance of spatial factor and network structure, limited territorial interchangeability of products and productive capacities;
- hierarchical character of the aggregate of transport objects of different scales (large, medium and small), including both objects of main networks and objects of regional networks;
- high sluggishness of investment processes caused by large capital intensity of transport objects, long terms of their projection, creation and performance;
- necessity and expediency of forming economically justified reserves of transportations capacity that, as a rule, exceed reserves of productive capacities in other industries, and their subsequent gradual development;
- realization of a considerable part of the effect of transport performance and development beyond itself - in industries it serves;
- excess, as a rule, of average costs over marginal costs in a wide range of changes in intensity of transport objects performance;
- specific structure of product cost, in particular, high share of wages and amortization, prevalence of energy resources costs in the total volume of current expenditure on materials;
- social character of consuming a number of important types of transport services, i.e. the absence of possibility to take into account volume of these services consumption by each separate consumer (in particular, services, rendered by motor roads and internal water tracks);
- non-determined character of dynamics of demand for transport services, changing in time character of loading transport objects.

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