This research combines theoretical approaches to assessing the role of science in the modern economy of the post-industrial transition. The research uses specific methods of analysis to study the condition and some current issues of transport services. The authors applied Lagrange multipliers method to optimize the transportation of wood products, studied road transportation in Ukraine using regression dependence, developed the information infrastructure of the transport company using graph theory, and determined the condition and prospects for the development of the transport industry in Ukraine based on trend analysis. The monograph has both theoretical and applied importance.

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Intellectualization of methods to improve the system of transport services

Monograph

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Imprint

Cover image: www.ingimage.com

Publisher:
LAP LAMBERT Academic Publishing
is a trademark of
Dodo Books Indian Ocean Ltd., member of the OmniScriptum S.R.L Publishing group
str. A.Russo 15, of. 61, Chisinau-2068, Republic of Moldova Europe
Printed at: see last page
ISBN: 978-620-4-74584-8

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INTELLECTUALIZATION OF METHODS TO IMPROVE THE SYSTEM OF TRANSPORT SERVICES

2022

CONTENTS

INTRODUCTION

A significant segment of Ukraine's modern economy undergoes the process of intellectualization and is based on high technologies and industries that use the latest innovations, intelligence and knowledge. Such areas of the national economy traditionally include rocketry, aircraft construction, medical and biotechnology, information technology and many others. Recently, certain segments of the service sector have been added to this list. The service sector is becoming dominant in the development context of many countries. In addition, it is closely intertwined with production technology. The space industry promotes the development of information technology, navigation, reliability of all kinds of transport and provides additional services in its operation. The development of aircraft construction helps to meet the demand for international transportation. The development of new computer equipment and software is widely used in all spheres of human life, including services, in particular, in tourism, hotel business, real estate services, advertising and all creative industries.

Transport services is one of the important areas of the development of services in general. Transport services provide flows of material goods in the process of creating new kinds of material welfare. At the same time, they are becoming increasingly important for improving the quality of life of individuals and society as a whole in the process of redistribution of material goods and in the process of their consumption. Air, rail and road transport operate today based on the use of intelligent technologies and scientific management methods. The spread of the knowledge economy as the main concept of social development leads to the development of services in general and transport services in particular.

At present, general theoretical approaches to the formation of the knowledge economy in the world have been analyzed by the classical economists and representatives of other branches of social sciences. Ukrainian scholars have sufficiently studied these issues, especially in adapting the knowledge economy to the conditions of the national economy. However, we believe that important methodological features of this service-oriented concept still need to be analyzed.

Knowledge and innovation are the determining factors for the formation and development of the post-industrial society. Such a developmental direction guarantees the leading position of a country in the economic sphere and strategic positions in the world geopolitics and geo-economics. In this case, the industrial type of economy cannot be completely replaced by a post-industrial one. Mining, agriculture, processing of raw materials and manufacture of goods for human needs remain a necessary condition for the existence of the society. However, new technologies are also being introduced into these processes, and these processes are becoming more social, resource saving and efficient.

The post-industrial society can be defined as a society of services, a new form of the society, based on the introduction of new post-industrial forms of economy, in which services dominate the sphere of material production, information and knowledge become major factors of economic growth, and creativity becomes a universal kind of work activity.

The services sector is developing at a fast rate and is also based on high technology and information systems (services), especially transport services. In the development practice of individual countries and regions, which are defined as post-industrial, we can observe trends of the transfer of large production capacities outside these countries and regions. This is especially true for the industries that are not environmentally friendly, and sometimes harmful to the environment and human health.

Therefore, for the further development of the economic system in Ukraine, it is advisable to study the general prospects of the transport industry in Ukraine, provide proposals for the creation of the information infrastructure of a transport company based on innovative management methods, provide scientific proposals for road transport and, in particular, transportation of woodworking products, taking into account modern logistics approaches and the use of intelligent technologies.

The authors of the monograph are Doctor of Sciences (Economy), Professor Olga Sazonets (Chapter 2, Conclusions) and Ph.D. in Economy Andrii Salenko (Introduction, Chapter 1).

CHAPTER 1.

KNOWLEDGE AS A DRIVING FORCE OF THE SERVICE SYSTEM DEVELOPMENT AND FORMATION OF THE POST-INDUSTRIAL SOCIETY

1.1. Services as the main factor of the economic growth in the knowledge economy

At the end of the twentieth century, the trend of transforming services into a key sector of the economy of developed countries began to take shape. This trend found its theoretical justification. D. Bell formulated the basic postulates of the theory of the post-industrial society. According to him, such a society is based on the development of the services sphere, and the technological basis of its development is knowledge. After the first theoretical justifications of the priorities for the development of services, especially innovative ones, initiated by D. Bell, new concepts were formed within this theory, which include those widely known to the scientific community and those that have not been sufficiently analyzed by experts yet. Such theories include the netocracy theory of Alexander Bard and Jan Soderqvist who represent the Stockholm School of Economics [1]. Based on the perception of a human being as a biological and social entity, these authors explore the emergence of a new dominant class of entrepreneurs – netocracy, and the gradual formation of a new class of workers – consumers.

The concept of information economy or information society of F. Machlup and T. Umesao [2, 3] is based on the analysis of consequences and forecasting the prospects for the development of a society and economy in the conditions of full informatization of all industrial processes, informatization of a social life of the person, penetration of information technologies into personal space of activity of each member of the society.

The theory of innovation economics is broader in the subject of the research. The impetus for its development was given by Joseph Schumpeter [4, p. 81 - 84]. The

broad subject of the theory of innovation economics has led to the separation of other areas of the economic research, such as neuro-economics, virtual economy, digital economy. All these scientific theories have one thing in common – they state that construction of a new type of society requires knowledge. The emergence of the concept of knowledge economy was the requirement of the time.

During the period of active development of economic integration in the 1980s, it became clear that the level of international competitiveness of a country is determined by the level of scientific knowledge, modern technology, staff skills. Japanese economist T. Sakaiya was the first to formulate a new trend – the knowledge economy. However, he also saw the first hidden contradictions of this theory. He warned that it could not be considered only as a transition to the dominance of services over production, or only as a simple reduction in the production of material goods [5, p. 337 - 371]. Scientists around the world consider his scientific postulate a bridge between the theory of post-industrial economy and the knowledge economy. The concept of post-industrial society methodologically combines modern social and economic theories.

Among the modern scientists who study the provisions of the theory of knowledge economy, we should single out prof. I.H. Khanin. His monographs "Institutional prerequisites for the functioning of the information space of the world economy" and "Noosphere path of knowledge and management" dealt with these issues. In his scientific works, he formulated a thesis about the priority of the development of society and economy based on the scientific and theoretical platform "Infosphere". This scientific and theoretical platform combines the advantages of rapid and constant trends in the information society, the dominance of the knowledge economy based on the creation of information and knowledge bases and human-centered, resource-saving, ethical approach to the noosphere theory [6. 7].

The applied aspects of the development of the knowledge economy were highlighted by prof. I.L. Sazonets. In the context of the research conducted by I.L. Sazonets, the liberalization of entrepreneurial activity is defined from the economic and organizational point of view as a system of new tools for finding and

implementing high technology through competitions, startups, engineering schools, operation and use of information and knowledge bases [8]. In the monograph "Determinants of liberalization of high-tech entrepreneurship in the post-industrial transition period", the researcher studied the impact of liberalization on the formation of high-tech entrepreneurship, identified determinants for the introduction of high technology in entrepreneurship, and suggested ways to improve management in high-tech business structures.

The social aspects of the development of the modern society in the new information and technological conditions were directly considered by prof. V.V. Dzhyndzhoian and I.L. Sazonets in the monograph "Social determinants of the development of services sphere within the concept of post-industrial society formation". The authors analyzed the social and scientific concepts of industrial and post-industrial economic development, areas of implementation of the principles of corporate social responsibility of enterprises in the context of "Concepts of state policy in promoting socially responsible business in Ukraine until 2030", areas of improving the efficiency of modern enterprises based on informatization services [9].

Despite the fact that general theoretical approaches to the formation of the knowledge economy in the world have been analyzed by the classical economists and representatives of other branches of social sciences and domestic scientists have sufficiently studied these issues, especially in adapting the characteristics of the knowledge economy to the national economy, important methodological features of this concept still need to be analyzed. The aim of this study is to identify information and knowledge as a driving force of post-industrial development.

The theories of economic development, which chronologically preceded in time, made the scientific basis for the methodology of post-industrial economy in the environment of knowledge economy. Prof. I.H. Khanin identifies the importance of the philosophical orientation of the economic knowledge in the ancient world, the recognition of economics as a synthesis of social sciences, and the importance of classical political economy. According to the author, classical economic theory is one of the most productive areas of the economic thought. Within its framework, a

number of economic theories were developed and a number of economic laws were identified. Classical economic theory also formulated the most important paradigm of economic science – labor theory of value. Following physiocrats, classical economists promoted economic liberalism. The school was actively developing in the late eighteenth century – 1930s. The author also identifies neoclassical areas of economics as an important basis of the knowledge economy. They include Keynesianism, monetarism, macroeconomics, and microeconomics. According to I.H. Khanin, institutional and neo-institutional theories also shape the global landscape of the knowledge economy (Fig. 1.1).

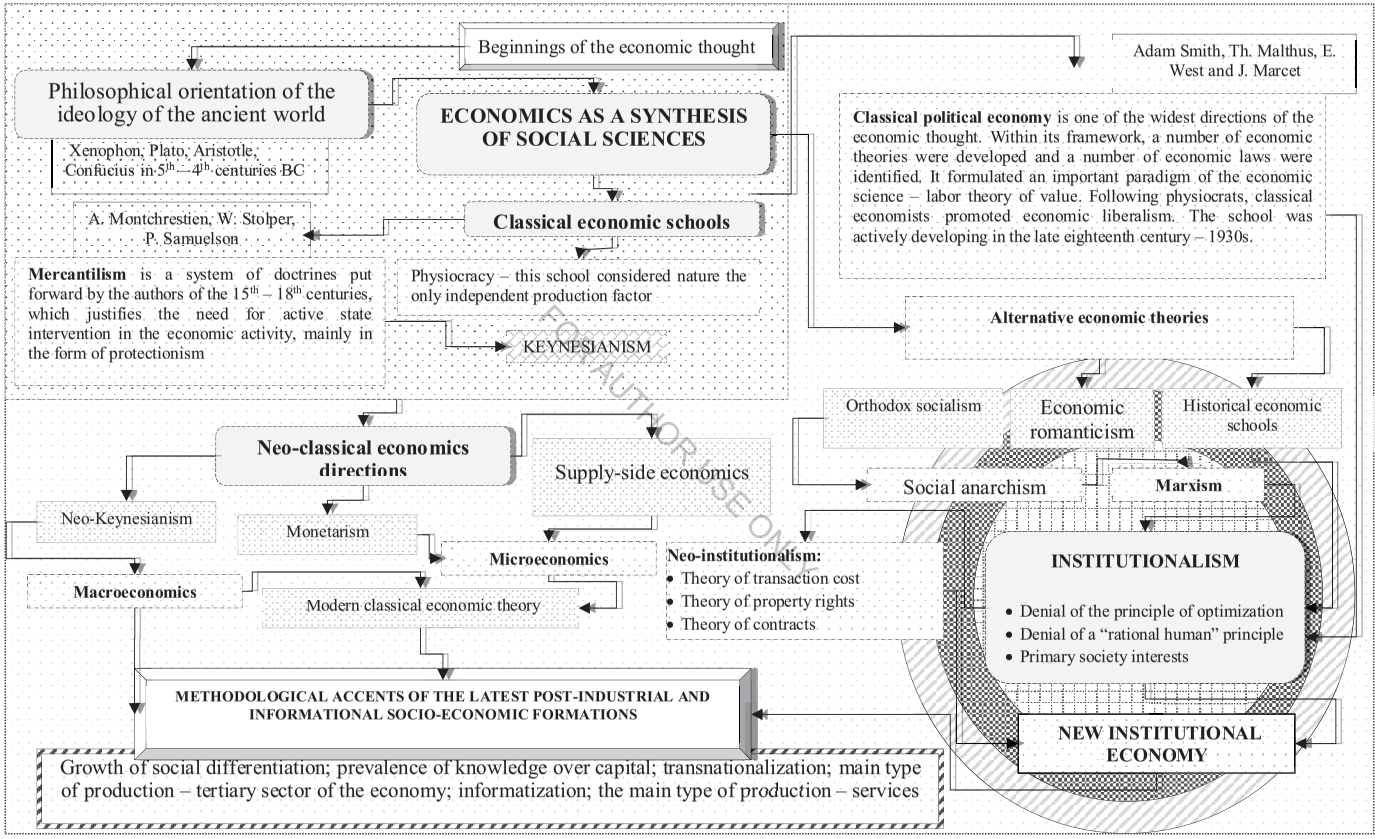

Fig. 1.1. Evolution of the paradigmatic forms of the economic thought in the concepts of the development of socio-economic formations [6]

In order to have an objective view of the whole picture of the development of post-industrial relations, it is necessary to analyze the consolidated information in the context of the world economic system. In this analysis, the statistical information is difficult to access and it is calculated with a long delay. In addition, such global statistic information is consolidated in other contexts.

However, at the theoretical level, prof. M. Poliakov identifies the identical features of post-industrial society theories and the theory of the knowledge economy. In his opinion: "common in the theories of post-industrialism and the knowledge economy is to determine the main processes of transformation of the industrial economy: changes in the industrial mode of production, type of relations, economic structure, emphasis on the development of knowledge, informatization, communications and human capital, social change (liberalism, mobility, etc.), the evolution of capitalism (post-capitalist system). ... The issue of forming new production systems, changes in the entire system of production relations under the influence of the spread of modern ICT become urgent and relevant. [10, p. 61 - 62]. Thus, the author emphasizes the change in the industrial method of production. Despite some areas of hyper-industrialization, services become the main driving force of economic development, and especially – scientific services. The author emphasizes the importance of a unified approach to the intensification of the communication systems, social change, which, in our opinion, is an important prerequisite for the development of social relations in the post-industrial society. The spread of modern information and computer technology, as declared by the author, forms the basis for closer communication between people located in different regions, although it can make less effective personal contacts among employees working in one office. Common factors of the theories of post-industrialism and the knowledge economy identified by M. Poliakov indicate the great similarity of these theories, as well as the creation of a basis for social change in the post-industrial society.

Based on a study of world economic thought regarding the formation of the knowledge economy, the author dwells on the main scientific principles of this theory, "The concept of the knowledge economy is based on the following key

provisions: knowledge becomes a key resource for the material welfare, creation of cost, value and income; knowledge is a dynamic object and factor of economic development; the results of economic activity increasingly depend on the efficiency of obtaining and using knowledge" [10, p. 38]. Such an approach determines the consistency of the author's scientific views with the classical perception of the knowledge economy. It is important that in his definition, the author directly links generation of knowledge to the economic development. In general, it is acceptable that the results of economic activity increasingly depend on the efficiency of obtaining and using knowledge, but it is traditional to perceive the active influence of the knowledge economy on high-tech sectors of the economy, although indirectly it affects other sectors of the economy that do not use high technology.

In general, according to M. Poliakov, "knowledge in economics can act in various aspects, in particular as: 1) resource or factor of production; 2) asset or capital; 3) outcome, product, commodity; 4) property" [10, p. 44]. In our opinion, this confirms the importance of knowledge as a social phenomenon that has a profound impact on the economic activity of an individual, country and society as a whole.

The category of knowledge is a multidisciplinary category. The essence of knowledge as a social phenomenon and the basis of post-industrial society is studied by scientists in different branches – philosophers, sociologists, lawyers, specialists in information systems, economists, and researchers of public administration. M. Poliakov also focuses on the problems of identifying the category of "knowledge". He believes that the difficulty of defining this category is due to the following reasons:

1) a variety of knowledge types that reflect a complex reality;

2) connection with the spiritual sphere and activities;

3) difficulties of objectification;

4) big share and importance of social (socio-humanitarian) knowledge, which is characterized by heterogeneity, variability, subjectivity, intuitiveness, low degree of validity and reliability;

5) large amount of implicit, hidden, individual (personal), "silent" knowledge

that is subjective and difficult to analyze;

6) complexity of the fixation in consciousness in the form of ideas, concepts [10, p. 38 – 39].

Our approach allows us to formulate the idea that knowledge as a driving force of post-industrial development should be divided into different categories: first, knowledge that directly affects the development of productive forces, secondly, knowledge that forms a system of high technology, thirdly, knowledge that forms the general high level of education and informatization of the society and indirectly affects post-industrial development, fourth, knowledge of socio-humanitarian nature, which forms the ethical basis of individual and social relations of the post-industrial society and accompanies the process of constant growth of productivity and production efficiency, fifth, human knowledge of their personality, which is based on the constant development of social sciences and humanities and combines the expansion of the worldview horizons, physical perfection, human health and spiritual development of an individual.

Such trends are inherent in the process of generating knowledge, both theoretical and applied. In modern science, there are trends to accelerate the process of the implementation of fundamental research into high-tech design solutions and finished products. M. Poliakov cites the following opinion of D. Bell, who singled out practical and theoretical knowledge, emphasizing the importance of the latter "the main thing in decision-making and change management has become the dominance of theoretical knowledge, the predominance of theory over empiricism and codification of knowledge into abstract symbols" [10, p. 42]. It should be noted that these words of D. Bell made a forecast for the future rapid development of the information technology and creation of the information economy. Later, among domestic scientists, such trends were studied by prof. O.M. Sazonets [11].

In accordance with the multidisciplinary approach in the definition of knowledge, M. Poliakov defines information as the basis for generating knowledge in the form of dissipative, multilayered, multilevel, different quality system, which is multifunctional and is both a resource and a product. It is used as a resource and

product and is the basis of biological, social, physical systems and therefore, its impact on the economic development is only a minor function in the tangible and intangible world. M. Poliakov's monograph "Knowledge economy: essence, determinants, global landscape" contains the following definition of information: "information is an intangible entity, a governing factor, a program of action for material, natural and social processes: intangible information governs the material world. Information is a resource and product of intellectual activity and performs functions as natural (the basis of the material world, the program of self-development of matter; the formation of living matter) and socio-economic (formation of a personality and society, means of communication, motivation, cultural (social) code, regulation of material-energy systems)" [10, p. 39]. From the point of view of analyzing the importance of information as a resource for the growth of the post-industrial society, it is important to define information as an action program for material and social processes, a means of communication, a factor in regulating material-energy systems. The use of these properties of information allows turning it into knowledge and use it as one of the main elements in the development of post-industrial social and economic systems.

Starting the presentation of his concept of the knowledge economy with the definition of information and knowledge, the author deepens the analysis and attempts to study the symbiosis of these two phenomena, trying to determine their natural unity. He states that "information can include the whole set of different facts available for human perception. At the same time, knowledge is not a concept other than information. Knowledge is information, but information of the highest quality. The main criterion for distinguishing the category of "knowledge" is, first and foremost, that we consider knowledge to be the information processed within human intellectual activity [10, p. 40].

Classical economic theory is one of the widest directions of the economic thought. Within its framework, a number of economic theories were developed and a number of economic laws were identified. It formulated an important paradigm of the economic science – labor theory of value. Following physiocrats, classical

economists promoted economic liberalism. The school was actively developing in the late eighteenth century – 1930s. It is also necessary to define as an important basis for the knowledge economy neoclassical areas of economics: Keynesianism, monetarism, macroeconomics, and microeconomics. Institutional and neo-institutional theories also shape the global landscape of the knowledge economy and post-industrial economy.

Despite some areas of hyper-industrialization, services (especially scientific) are becoming the main driving force of the economic development. The spread of modern information and computer technology forms the basis for closer communication between people located in different regions, although it can make less effective personal contacts among employees working in the same office. The common factors of post-industrialism theories and the knowledge economy indicate the great similarity of these theories, as well as the creation of the basis for radical change in the post-industrial society.

The category of "knowledge" is a multidisciplinary category. The essence of knowledge as a social phenomenon and the basis of the post-industrial society is studied by scientists in different branches – philosophers, sociologists, lawyers, specialists in information systems, economists, and researchers of public administration. The difficulty of defining this category is due to subjective and objective reasons.

From the point of view of analyzing the importance of information as a resource for the growth of the post-industrial society, it is vital to define information as an action program for material and social processes, a means of communication, a factor in regulating material-energy systems. The use of these properties of information allows turning it into knowledge and use it as one of the main elements in the development of post-industrial social and economic systems.

1.2. Knowledge and innovation in the development of the service economy and post-industrial society

Among the countries that have made significant progress in increasing their gross domestic product and population welfare should be distinguished those that have different specializations of the economy. The United States, Japan and European countries are among the leaders in technological development, the Persian Gulf countries and Northern Europe are among the countries with hydrocarbon reserves, the Caribbean and other small countries in different parts of the world are tourist centers. However, the priority of the economic development is the further investment of accumulated financial resources in the economy, which requires the concentration of knowledge and innovation. Knowledge and innovation are the determining factors for the formation and development of the post-industrial society. Such a developmental direction guarantees the leading position of a country in the economic sphere and strategic positions in the world geopolitics and geo-economics. In this case, the industrial type of economy cannot be completely replaced by a post-industrial one. Mining, agriculture, processing of raw materials and manufacture of goods for human needs remain a necessary condition for the existence of the society. However, new technologies are also being introduced into these processes, and these processes are becoming more social, resource saving and efficient. Such trends determine the priority of knowledge and innovation as the main characteristics of the further development of the society and economy in the post-industrial dimension.

Qualitative processes of the transformation of productive forces, development of innovations and high-tech sphere, which influence changes in the essence of labor and development of new social relations were studied by such scientists as V.S. Bilozubenko, M.H. Bilopolskyi, I.P. Bulieiev, T.V. Hrinko, O.I. Datsii, N.P. Meshko, M.V. Poliakov, O.M. Sazonets, K.S. Saliha, A.H. Semenov, S.Yu. Khaminich, O.I. Yastremska. The works of these scientists dealt with the problems of the industrial potential of Ukraine and its restructuring in terms of expanding the importance of services; informatization of the world economic

development and national economy; formation of the new approaches to the economic management based on the knowledge economy; increasing the impact of education and science on the effective functioning of the national economy; promoting the activities of innovators in various sectors of the economy and in corporations.

In this research, we intended to combine an overview of the classical approaches to the analysis of the post-industrial society and provide scientific explanations for the emergence of new trends in the development of different countries. Therefore, the aim of this research is to analyze the scientific categories of "knowledge" and "innovation" as determinants for the formation and development of the post-industrial society and identify different views of scientists on the evolutionary changes in the new society.

The terminological definitions of the post-industrial trends in the society and economy used today in the scientific literature contain different interpretations. In the monograph "Tax activity of the state in the formation of the informational post-industrial economy", I.A. Maksymenko emphasizes that the term "theory of the post-industrial society" is used in a narrow and broad senses. In the narrow sense, it directly studies the third, higher stage of human civilization. Broadly, this theory studies all stages of civilizational progress – pre-industrial, industrial and post-industrial, because without a broad approach, it is impossible to reveal the essence of the post-industrial society, its origins, principles and essential features" [13]. Perhaps, the scientist comes to such conclusions due to the fact that in practice, before the emergence of the scientific works related to the theory of the post-industrial society, scientific methodology did not consider the three stages of the economic and social development (agricultural, industrial and post-industrial) as different stages of a single evolutionary development, characterized by the level of the use of information and knowledge as determining factors in this development. It can be argued that modern scientific approaches study the third phase of the society development – post-industrial, but using a dialectical approach. In the process of research, they turn to the analysis of all three stages. Such an approach adds clarity to the scientific analysis.

The term used by scholars who study post-industrialism – "dematerialization" – also has a scientific basis and very clearly describes the trend in the society. Based on this approach, we can identify the following trends: the industrial basis of the society continues to exist and deindustrialization is not a necessary element of the post-industrial development; the share of services in the total product (national, world) is growing at a faster rate; among the services, the most important are information services and services aimed at the development of science and innovation; in the real economy sector, high-tech industries are growing faster, ensuring international competitiveness of national economies; in the traditional branches of the national economy, innovations are beginning to be applied at a faster pace.

Scientists also use the term "post-material motivation", which is more the subject of research by sociologists and political scientists. In our opinion, the distinctive features of post-material motivation are full access to information, individual nature of incentives, increasing tendency to differentiate payments, new approaches to assessing the quality of services, high professional qualities of employees, and high living standards.

The main characteristics (components, determinants) of the post-industrial society, which are already inherent in the most highly developed countries of the world, are known and indisputable. They can be classified as follows:

1. Science becomes a real driving force in the development of the economy and the country as a whole. Well-known innovator and scientist M. Poliakov presents methodological approaches that can be used to study the impact of science on the formation of the post-industrial society, which once again proves the multidisciplinary character and complexity of the process of studying this phenomenon (Table 1.1). These approaches are also being studied by scientists [19, 20].

Table 1.1

Approaches to the study of knowledge as the basis of the post-industrial society [10]

Approach	Characteristics of the approach
Philosophical	Knowledge as a phenomenon of social development
Sociological	Knowledge as a social value
Economic	Knowledge as a manifestation of private and public welfare, a resource of economic activity
Informational	Knowledge as a defining information component of life
Behavioral	Knowledge as an object in the actions of individuals and social groups
Functional	Knowledge as a basis for a number of functions of different actors and for elimination of contradictions in social and economic systems
Civilizational	Knowledge as a key resource for the development of civilization

2. The share of business and enterprises related to the industrial sector declines;

3. Sectors that generate new and traditional services have an increasing share in the national income of countries and in the world economy as a whole;

4. The professional structure in the economy and society as a whole changes. An increasing share is occupied by creative professions, highly qualified specialists and managers. A wide stratum of people leading a bohemian lifestyle is being formed;

5. Labor is being transformed. An increasing number of professionals have the opportunity to work online, have a free schedule, and work as freelancers;

6. A new phenomenon in the generation of services spreads. Today, it is called “prosumerism” due to the new nature of labor activity, which combines in one person the features of both a consumer and a seller;

7. A new institutional structure of the economy, statehood and society is being formed. In it, educational, scientific, and high-tech institutions occupy a leading place, and other traditionally influential institutions, such as public administration, legal framework, civil system and non-governmental institutions subordinate their activities to the development of science;

8. Innovation culture emerges as a new type of culture. It is connected with the ideological and methodological orientation of this historical type of culture to innovations in all spheres of human life and activity, to their comprehensive

production and replication on a global scale. Prof. M.V. Poliakov suggests the main elements of the international system (network) of global innovations (Table 1.2).

Table 1.2

Components of the global innovation system and their elements [10]

Components of the global innovation system	Elements of the components of the global system
Generation of knowledge	scientific communications, co-creation, sources (carriers) of knowledge;
Transformation of knowledge	chains of knowledge organization, distributed knowledge base;
Communication (transfer of knowledge)	transactions, interactions, information exchange (flows), social capital, mechanisms of partnership interaction;
Management (management of knowledge)	forms of organization and interaction, hierarchies, procedures, social environment, formal and informal institutions, etc.;
Economic mechanism	social and economic, industrial relations, financial flows, methods of commercialization.

In his article "Daniel Bell's concept of the post-industrial society as a basis for the information society concepts", E.A. Kalnytskyi emphasizes that Bell's term "information society" is a new name for the post-industrial society, a term that emphasizes the basis of its social structure – information. Bell introduces this term in his work "The social framework of the information society", although from today's point of view, the concept of "knowledge society" would be more correct and promising [14, p. 137 - 142].

This idea is actively promoted in the research of M.V. Poliakov. In the monograph "Knowledge economy: essence, determinants, global landscape", he provides the basic postulates of the knowledge economy, analyzes current trends in its development and identifies prospects for the economic development and society based on the knowledge economy in the context of the post-industrial society. The scholar highlighted the theoretical and methodological foundations of the knowledge economy research, analyzed the process of the formation of the global space for the knowledge economy, provided analytical characteristics of the global landscape of the knowledge economy, identified methods of knowledge management in international business, trends and tools of this process, identified strategic priorities for the formation of the knowledge economy in Ukraine in a global context [10,

p. 688]. According to the author, there are "six determinants of the functioning of the knowledge economy: science, education, entrepreneurship, information and computer technology, science-intensive production and innovation systems". The five components are closely linked and focused solely on creating new value through different ways and directions of generating, transforming and using knowledge. The determinant "entrepreneurship" consists of the following components: global innovation networks; international business; sale of goods and services; diffusion of innovations; venture capital movement; purchase and sale of knowledge and data; joint business structures, etc. Despite the generally innovative and creative nature of this component, it can be said that international business, sales of goods and services, and joint business structures do not necessarily reflect actions in the field of science and high technology development. Therefore, it can be concluded that the "post-industrial society" as a definition more broadly reflects changes in modern forms of labor and means of production than the definition "knowledge economy".

Gradual changes in the structure of the economy and the nature of labor lead to global changes in human life. In the article "Evolution of the theories of the post-industrial society", L.I. Lebedeva notes that all changes in the new society can be divided into three subgroups: cultural, economic and socio-political [15].

In the cultural sphere, they "include reducing the impact of traditions on people's lives, expanding opportunities and ways for human development. In modern conditions, the forms of communication between people are changing" [15]. The practice of the distance organization of the educational process, managerial and scientific activities leads to the transfer of this form of communication to personal communication. In addition, the rapid level of globalization and internationalization of all spheres of human activity requires new forms of distance communication. Unified rules and norms of behavior for citizens of all countries in public places, transport, and recreation areas lead to greater multiculturalism, interpenetration of cultures and traditions of different countries and form new views on their perception.

In the economic sphere, they lead to "the formation of a global network of capital organization; growing use of scientific and technical developments in the

business environment; transformation of science into a direct productive force and growth of the intangible sector of production; increase in white-collar employment and, consequently, decrease in blue-collar employment; demassification of production, creation of "individual" goods; decentralization of production management and transition to a network method of labor organization" [15]. As it can be seen, in the economic sphere, changes have a broad impact on people's lives. The tendencies towards the formation of a global network of capital organization can already be seen today. In our opinion, this formation includes such factors as increase in the scale of multinational corporations, creation of a global network of financial and investment activities of international organizations, financial and investment activities in the field of large-scale projects within international integration organizations. As for other economic changes stated by L.I. Lebedeva, they already actively manifest themselves in the economic system and influence the formation of new economic processes and trends.

In the socio-political sphere, these changes include "reducing of the role of national states in governing the society due to the complexity of management tasks, expanded political participation of citizens and increase in the role of transnational corporations; the crisis of a single nuclear family and the emergence of its various kinds, etc." [15]. The first two features of the post-industrial society identified by the author – reducing of the role of national states in governing the society, expanded political participation of citizens and increase in the role of transnational corporations – have been studied extensively by economists and other scientists. As for the transformation of a nuclear family, economists and representatives of other sciences do not have a single concept and vision of this change. It is clear that the dynamics of life, as well as the pace of creation and development of business will increasingly affect family relationships. Members of a nuclear family cannot communicate with their spouses and children using mostly information networks. Today we can see the tendency to create incomplete nuclear families, in developing countries there are more and more same-sex families, reproduced families. The next decade is to

determine which model of family creation and functioning will be acceptable or even dominant in the post-industrial society.

It should be noted that the transition from the economy of production of goods to the economy of services does not mean a reduction in production. A striking example of the rapid growth of services is the food trade. We cannot say that retail chains are shrinking, but despite the fact that the number of supermarkets grows, such services as goods delivery also rapidly develop. There appear many private companies that specialize in delivering custom products; the same trends are noticeable in the development of catering companies. It is also worth noting that despite the development of the professional and technical employees, the stratum of the creative intelligentsia, artistic and creative professions and the population leading a bohemian lifestyle is growing at a significant pace. At the same time, the social role of theoretical knowledge as a source of innovation and political formulations is increasing, but this process is segmented and directed opposite to the realities of the industrial society: the state directs funding for science to develop applied projects, while the money of private investors and large corporations is invested in theoretical research. Theoretical research is also being developed in the world's leading countries based on public-private partnerships. In addition, major scientific and technological projects that are being implemented today (for example, NASA Moon Program) are characterized by the fast implementation of theoretical research into practical technological achievements. In 2020 alone, SpaceX, Blue Origin, and Dynetics signed agreements with NASA amounting $ 967 million. These funds had to be used for the development of basic theoretical concepts for the delivery of modules and people to the Moon. At the same time, a human landing on the Moon and the creation of a permanent station on it is planned for 2024. This once again confirms the changing approaches to the leading social role of theoretical knowledge as a source of innovation.

Some scholars see the contradictory nature of the post-industrial society in the fact that the rapid development of science and technology does not find a rapid objective assessment in the society in terms of moral and humanistic values.

K.M. Kyrylenko notes, “There is another important characteristic of a human being in the post-industrial society, as well as of the society itself. The level of the development of science and technological possibilities of production, which are rapidly evolving, are so powerful that they can be very useful for humans and at the same time harmful not only for the humans but also for all living things on the planet and for the planet itself. Therefore, the importance of humanitarian examination of human knowledge and of the ethical component of modern technology is relevant and urgent” [16, p. 45 - 51]. Currently, this trend is leading to the emergence of global documents in the field of ecology, nature management, social movements and organizations in this field.

These individual imperfect points of the post-industrial society theory may be due to the main shortcoming, which was formulated by S.V. Mochernyi. According to him, “the methodological flaw of the post-industrial society theory is primarily a characteristic of the society only from the standpoint of one side of the economic system – the productive forces and partly – from the standpoint of the social division of labor (and in their unity – from the standpoint of the technological mode of production). However, even in this case, the analysis of the new stage is incomplete, because the productive forces include other elements, in particular, means of production, human resources, information, and others. Adherence to the principles of …systematics requires the addition of such a characteristic of property relations, especially economic. … Even with the development of the society based on the principle of equality of results, relations are formed and function on the appropriation of the results of scientists, intellectual property” [17, p. 952].

Based on the conducted research, it is necessary to draw the following conclusions:

the theory of the post-industrial society is used in a narrow and broad senses. In the narrow sense, it directly studies the third, higher stage of human civilization. Broadly, this theory studies all stages of civilizational progress – pre-industrial, industrial and post-industrial, because without a broad approach, it is impossible to

reveal the essence of the post-industrial society, its origins, principles and essential features;

post-material motivation is characterized by full access to information, individual nature of incentives, increasing tendency to differentiate payments, new approaches to assessing the quality of services, high professional qualities of employees, and high living standards;

gradual changes in the structure of the economy and nature of labor lead to global changes in human life. All changes in the new society can be divided into three subgroups: cultural, economic and socio-political;

science becomes a real driving force of the economic development and a country as a whole. M. Poliakov suggests methodological approaches that can be used to study the impact of science on the formation of the post-industrial society, which once again proves the multidisciplinary character and complexity of the process of studying this phenomenon;

the state directs funding for science to develop applied projects, while the money of private investors and large corporations is invested in theoretical research. Theoretical research is also being developed in the world's leading countries based on public-private partnerships. There is a change in approaches to the leading social role of theoretical knowledge as a source of innovation.

1.3. Determinism of the theories of the industrial society and its transformation into the post-industrial one

Scenarios for the development of the future society are based on the approaches that include determinants of social development, determine the humanistic ideals of development and highlight the increasing importance of an individual in the society. Among the approaches that determine such scenarios, the dominant role belongs to the theory of the post-industrial society development. The history of the formation of this term and the evolution of the approaches to the definition and formulation of the factors influencing this society is well known.

Classical economists and representatives of other social sciences laid the foundations of such a doctrine.

To give the essence of the classical approach to defining the post-industrial society, it is enough to quote D. Bell: "The post-industrial society is a society in the economy of which the priority has shifted from the predominant production of goods to the production of services, research, organization of the education system and improving the quality of life; in which the class of technical specialists has become the main professional group and, most importantly, in which the implementation of innovations depends largely on the achievements of the theoretical knowledge ... The post-industrial society... presupposes the emergence of an intellectual class whose representatives at the political level are consultants, experts or technocrats" [21].

The description of the evolution of the post-industrial society theory and its main essence is quite logically presented in the report by V.M. Horovoi "Terminological characteristics of the post-industrial society". In particular, the author notes that at present, according to the characteristics of production, civilizational progress is divided into three main stages: pre-industrial – with the development of extractive economic activities, industrial – with the development of processing technologies and machine production, and post-industrial – with the growing importance of data processing, use of information resources, and improvement of the production and social organization of the society. This division covers large periods of human history and is a very general reference point for the present. The modern post-industrial stage of human development needs a more detailed gradation in terms of understanding the hierarchy of the content of information processes that take place in it [22]. In the monograph "Determinants of liberalization of high-tech corporate entrepreneurship", I.L. Sazonets determines the main characteristics of the post-industrial society and the criteria for its identification [8]. In the fundamental work of M. Poliakov "Knowledge economy: essence, determinants, global landscape" the post-industrial society is seen as a society based on knowledge [10].

Based on many works of scientists, who study the problems of the post-industrial society, it is necessary to identify some theoretical areas that, in our opinion, are still insufficiently studied. Therefore, the aim of this research is to define the post-industrial society based on the development of theories of technological determinism and industrial society.

The formation of a modern system of the research in the post-industrial economy began with the first attempts to analyze the formation of the industrial economy. V.I. Shtanko gives a brief description of the scientific thought that justified the formation of the industrial society. In particular, he notes that "in the twentieth century, there were quite common concepts< which argued that the basis of the social development is the development of technology. The first recognition of the significant role of science and technology in the development of the society took place in the era of modern times and the Enlightenment. Francis Bacon's "New Atlantis" (1627) argues that the progress of humankind and its constant prosperity are ensured through the development of science and technology: "knowledge is power". It is at that time, according to many researchers, that a special concept of understanding social development – technological determinism and a special type of civilization and cultural development – manmade civilization were formed" [23, p. 6 - 7].

Francis Bacon was one of the first scientists to embark on the path of empiricism and to lay the foundations of a materialist approach to the process of cognition. In the book "New Atlantis", he expressed views that are largely consistent with the ideas of T. Moore and T. Campanella, but are based on specific examples, forecasts and understanding of modern methods of organizing the national economy, the benefits of new technologies, and the importance of new knowledge. This work was one of the last in his scientific legacy, so it absorbed all the experience of his work as a politician, sociologist, and public official.

The industrial or production society is a society formed in the process and as a result of industrialization, development of machine production, emergence of adequate forms of labor organization, application of scientific and technological

progress. It is characterized by flow production, mechanization and automation of labor, development of the market of goods and services, humanization of economic relations, the growing role of management, formation of the civil society [24]. The term was introduced by the French philosopher and sociologist Henri de Saint-Simon.

D.V. Trubitsyn defines the further development of theories of the industrial/post-industrial society in the context of such a direction of economic science as technological and economic determinism. He notes, "the direction of technological and economic determinism is represented by the theories of industrial/post-industrial society [Aron 1968; Bell 1999; Giddens 1999; Galbraith 2004; Drucker 1999; Sakaiya 1999; Stewart 1999; Touraine 1998]. Their general provisions on the transformation of the agricultural society into the industrial and then post-industrial, in fact, form the basis of the theory of the modernization in this methodology. Beginning from the first half of the nineteenth century, when Saint-Simon first introduced the concept of the "industrial society", this theoretical line has been constantly evolving" [25].

A. Saint-Simon as a scientist who defined the priorities of industrialization should be especially noted. Many of his compatriots at the time even considered Saint-Simon an English spy for his extensive promotion of the benefits of the industrial development. One of Saint-Simon's main theses was the industrialization of the French economy in order to ensure leadership in the international and economic spheres in the international arena. Saint-Simon is a well-known figure as a social scientist who studied all areas of the social, political, economic development of France, Europe and the world at large. However, some provisions of his worldview, such as associations of producers (in the future – the process of pooling capital and creating corporations), the impact of property on the effectiveness of country governance and economic development, the place of the state in managing social and economic processes (in the modern interpretation – the concept of "service" state) allow identifying A. Saint-Simon as a scientist, who made a significant contribution to the theory of the economic development, and who, in particular, was a supporter

and representative of the technological determinism and advocated the need for industrialization.

It is necessary to note the great contribution of domestic scientists I.L. Sazonets and O.M. Vivsiannyk in the study of the scientific heritage of A. Saint-Simon. From the point of view of A. Saint-Simon's study of the processes of institutionalization, the authors identified the main achievements of his worldview and scientific paradigm of the social development (Table 1.3).

Table 1.3

The impact of institutions on the social and economic development according to A. de Saint-Simon [26]

№	Institution	The impact of institutions on the social and economic development according to A. de Saint-Simon
1	Producers' associations in the field of economics	The main features of the "industrial system" are the process of transforming the society into a general association of people, the introduction of compulsory productive labor, opening equal opportunities for all to use their abilities and the introduction of distribution "by ability", state planning of industrial and agricultural production, transformation of the state power into a tool of production organization.
2	Association of countries as the political system of Europe	The state must become a tool of centralized and planned production, turn rule of humans into the rule of things, and the union of states into a world association of peoples without borders in the name of the triumph of universal equality and universal peace.
3	Religion as the main institution of statehood	In "An essay on the science of man", Saint-Simon points to religion as a major political institution and seeks to identify the role it had played throughout European political history.
4	Parliamentary system as a democratic institution in public administration	Of course, the form of parliamentary government is much better than any other is, but this is only the form, and the institution of property is the essence; it is this institution that serves as the basis of social structure.
5	Institute of property	The institute of private property, therefore, must be preserved, but property will not be formed through existing unjust mechanisms, for example, through the institution of inheritance, but solely based on the work of each member of the society. Harmonious reconciliation of private and public interests and reasonable competition will ensure freedom, prosperity and political stability of the state.
6	Institute of royal power	The institute of the royal power has a general character that distinguishes it and puts it above all other institutions. Its existence is not connected with any political system at all. This institute will

		apply equally to all systems of social organization, the establishment of which may require the progress of civilization.
7	Constitutional institutions	The Charter taught them to think about their place in the system of constitutional institutions. The Hundred Days Government recognized the power of commerce and industry, even believing that it could not better prove the sincerity of its liberal positions. Since the beginning of the Second Restoration, the new government established itself.
8	Concept of the "service" state	Governments will no longer control the people; their functions will be limited to removing everything that hinders useful work. They will have little power and little money, because little power and little money is enough to achieve the goal.

According to V.I. Shtanko "the main ideas of the concept of the industrial society were formulated in the works of American economist Walt Whitman Rostow "The stages of economic growth: a non-communist manifesto" (1960) and in the lectures at Sorbonne by French philosopher Raymond Aron (1956 – 1959). Rostow believes that there are five stages in the development of humankind – "traditional society"; "period of preconditions" or "transitional society"; period of "takeoff" or "shift"; period of "maturity" (industrial society) and the era of "high levels of mass consumption", the ideal type of which Rostow considers the "Anglo-American model". Further, the ideas of the industrial society were developed in the works of French sociologists R. Aron and J. Fourastie, American economist D. Galbraith, American sociologists Z. Brzezinski, W. Fowns and others [23].

V. Liakh emphasizes that D. Bell "even clearly defines the time point of transition to a new phase of development: 1956, when the number of white-collar workers (i.e. highly qualified workers) began to exceed the number of blue-collar workers (lower-level workers)" [28].

In the modern interpretation of the tendencies of the post-industrial society development, the authors determine the priority of the development of the information-communicative and information-technological component. We find a broad interpretation of these processes in the works of prof. V.M. Hrynov. In his work "Knowledge as the main resource of modern economy", he states, "in the theory of the post-industrial society, technological progress and codification of

theoretical knowledge have become determinants of the formation of a new society, and the evolution of humankind is viewed through the prism of knowledge progress. The vast majority of researchers mentioned as the main features of the post-industrial society a radical acceleration of technological progress, reducing of the role of material production, which was expressed, in particular, in reducing its share in total social product, development of services and information, changing motives and nature of human activity, emergence of a new type of resources involved in production, a significant modification of the entire social structure" [29].

Together with the term "post-industrial society", scientists use the term "post-industrial economy". This is especially true for economists. We agree with the opinion of L.I. Lebedeva. In the article "On the methodology of research in the post-industrial economy", she notes that the term "society of the future" is understood as a society where the service sector dominates the sphere of material production, information and knowledge become the main factors of economic growth, creativity becomes a universal work activity [30].

L.I. Lebedeva does not define the post-industrial economy as a part of the post-industrial society that generates added value. Based on her interpretation, it can be stated that a post-industrial society is a new form of the society, formed by the introduction of new post-industrial forms of economy where the service sector dominates the sphere of material production, information and knowledge become major factors of economic growth, and creativity becomes a universal work activity. Thus, in her opinion, the term "post-industrial society" can also be understood as a society with new characteristics that emerges based on the post-industrial economy. From this point of view, "post-industrial society" is a community of people who have a positive attitude to creative work, innovation, the structure of employment of which is dominated by the service sector (due to the increasing work productivity)" [30].

The given author's definition agrees with the opinion of H.V. Zahrai. In the article "Analysis of approaches to defining the concept of post-industrial economy, its features and causes", he states that modern economic literature on business

practice displaces the concept of "post-industrial" economy, introducing more specific categories:

– "knowledge economy", the main direction of which is "knowledge management",

– "service economy" in its definition emphasizes the change in the result of work in the post-industrial society, most outcomes are not material products, but services;

– "innovation economy" and "innovation management" are manifested in the innovative nature of the intangible product, followed by innovative tangible products.

– "information economy", in which information is the main commodity [31]. Prof. O.M. Sazonets conducts her research and reveals the trends of the modern world economy from this scientific standpoint [35].

H.V. Krushelnytska clarifies the components of the post-industrial economy stating, "The post-industrial economy of this society is based on science-intensive technologies, information and knowledge, the widespread use of innovation, which requires training and continuing education and includes information economy and knowledge economy" [32].

Thus, we should especially note A. Saint-Simon as a scientist who determined the priorities of industrialization. Many of his compatriots at the time even considered Saint-Simon an English spy for his extensive promotion of the benefits of the industrial development. One of Saint-Simon's main theses was the industrialization of the French economy in order to ensure leadership in the international and economic spheres in the international arena. Some provisions of his worldview, such as associations of producers (in the future – the process of pooling capital and creating corporations), the impact of property on the effectiveness of country governance and economic development, the place of the state in managing social and economic processes (in the modern interpretation – the concept of "service" state) allow identifying A. Saint-Simon as a scientist, who made a significant contribution to the theory of the economic development, and who, in particular, was a supporter and

representative of the technological determinism and advocated the need for industrialization.

We can state that the post-industrial society is a new form of organization of the society, which is formed based on the new post-industrial forms of economy where services dominate the sphere of material production, information and knowledge become major factors of economic growth, creativity becomes a universal work activity.

1.4. Transformation of scientific activity and the role of a scientist in the process of forming the knowledge economy

Among the main driving forces of the development of the service system and formation of the post-industrial society, we have identified scientific activity as the main one. The founder of the theory of the "future post-industrial society" was D. Bell. Alexander Bard and Jan Soderqvist [1], who represent the Stockholm School of Economics, developed an interesting theory of netocracy. The concept of information economy or information society became the continuation and development of these theories. F. Machlup and T. Umesao [2, 3] simultaneously made this theory public to the scientific community in the United States and Japan. In his works, Joseph Schumpeter identified that research in the field of innovative economics deals with the relationships in all areas of scientific knowledge connected to economic growth, although, of course, this research traditionally considers those areas that directly affect the rapid implementation of creative ideas in science-intensive industries, new technology and profit [4, p. 81 - 84]. The latest development in these scientific concepts was the concept of Japanese economist T. Sakaiya. He formulated the concept of knowledge-based economy. The practical implementation of this concept in Japan currently allows this country to have one of the most efficient economies in the world. [5, p. 337 - 371].

M.V. Poliakov's monograph "Knowledge economy: essence, determinants, global Landscape" is fundamental scientific research conducted in recent years on the

problems of functioning and development of the knowledge-based society in Ukraine. The aim of this research is to identify the social determinants of changes in the nature of scientific work and individual work of a scientist in the global landscape of the knowledge economy according to M. Poliakov. Such a study can be carried out by analyzing the monograph by M. Poliakov "Knowledge economy: essence, determinants, global landscape" [10].

The main postulates of the scientific approach to the knowledge economy as a civilizational aspect of general post-industrial development in its theoretical interpretation are the same for both the post-industrial theory and knowledge economy, however, the author sees some methodological differences. In the monograph, he argues that:

first, industry reached a large scale and functioned efficiently, which allowed in the second half of the twentieth century to speak about the emergence of an economy with a predominance of services. Without accumulated industrial capital, this would be impossible;

second, …Production of service, information products and communication will not replace an industrial product, so we cannot speak about …dominance of services;

third, in connection to robotics, even hyper-industrialization is possible. At the beginning of the twenty-first century, we are speaking about the fourth industrial revolution, not the service revolution [10, p. 61 – 62].

This author's approach is aimed at defining a post-industrial society as a society in which both the industrial sector and the service sector are developing, although the author does not aim to study this issue. However, we can determine that the services sector is developing at a faster pace and it is also based on high technology and information systems (services). In the development practice of individual countries and regions, which are defined as post-industrial, we can observe trends of the transfer of large production capacities outside these countries and regions. This is especially true for the industries that are not environmentally friendly, and sometimes harmful to the environment and human health. Therefore, statistics on the economic development of these countries can provide indicators of

very rapid growth of services in relation to production.

Such an approach echoes the research of prof. I.H. Khanin who combined in his works the study of trends in the information society and the noosphere paradigm of human development, by academician V.I. Vernadsky. His monographs "Institutional prerequisites for the functioning of the information space of the world economy" and "Noosphere path of knowledge and management" dealt with these issues [6. 7].

In general, according to M. Poliakov, "knowledge in economics can act in various aspects, in particular as: 1) resource or factor of production; 2) asset or capital; 3) outcome, product, commodity; 4) property" [10, p. 44]. In our opinion, this confirms the importance of knowledge as a social phenomenon that has a profound impact on the economic activity of an individual, country and society as a whole. As a resource or factor of production, knowledge is used by high-tech corporations in order to gain leadership in world markets in certain areas of economic activity. As an asset or capital, knowledge is also used for this purpose, but can be equivalent to other material and financial values, and form new property through individual-collective (corporation) or joint-corporate (concern, holding, association) activities. As an outcome, commodity (product of knowledge), knowledge is used by specialized corporations that generate and sell it or high-tech corporations that generate and use it in their further activities. The transfer of knowledge, its purchase and sale require its materialization and formalization.

In the world, there are developed institutional and legal mechanisms for such formalization. They exist both globally – the World Intellectual Property Organization (WIPO), which aims to promote the protection of intellectual property around the world by ensuring cooperation between states and compliance with multilateral treaties regulating the legal and administrative aspects of intellectual property and at the level of national economies in the form of a system of legislative and regulatory documents. Some applied mechanisms of such formalization were studied by prof. I.L. Sazonets. In the monograph "Determinants of liberalization of high-tech entrepreneurship in the post-industrial transition", the researcher explored

the theoretical foundations of business liberalization and its impact on the formation of high-tech entrepreneurship, identified determinants of introducing high technology in entrepreneurship, including some institutional norms and rules, proposed areas for improvement of management systems in high-tech business structures [8].

M. Poliakov cites the following opinion of D. Bell, who singled out practical and theoretical knowledge, emphasizing the importance of the latter: "the main thing in decision-making and change management has become the dominance of theoretical knowledge, the predominance of theory over empiricism and codification of knowledge into abstract symbols" [10, p. 42]. It should be noted that these words of D. Bell made a forecast for the future rapid development of the information technology and creation of the information economy.

Starting the presentation of his concept of the knowledge economy with the definition of information and knowledge, the author deepens the analysis and attempts to study the symbiosis of these two phenomena, trying to determine their natural unity. He states that "information can include the whole set of different facts available for human perception. At the same time, knowledge is not a concept other than information. Knowledge is information, but information of the highest quality. The main criterion for distinguishing the category of "knowledge" is, first and foremost, that we consider knowledge to be the information processed within human intellectual activity [10, p. 40].

From this opinion of the author, we can conclude that information becomes knowledge only if it interacts with the social system. Knowledge in its essence is a social category. On the one hand, an individual, as a researcher transforms information into knowledge, on the other hand, individual intelligence is virtually unable to generate knowledge alone. This provision allows determining the basic prerequisites for social interaction in the process of generating knowledge.

First, a scientist who, in the early days of human development, generated knowledge, had to rely on the accumulated empirical experience, and one generation of people was not enough to accumulate such experience.

Second, modern scientific research is conducted in large research teams and

breakthroughs in scientific and technological development are possible with the cooperation of creative innovators with other colleagues in the team, in which each member has own functions. It should be noted that this leads to the emergence of a new type of management – research management. A common phenomenon in research today is the generation of knowledge through the implementation of research projects. Such projects consist of many organizational and financial components and are implemented by specially formed teams.

Third, modern research projects are based on the following organizational and preparatory decisions:

project planning as a component of research project management;

research project management system;

research project cost management;

research project quality management;

research project time management;

research project risk management;

information communication in a research project;

formation and development of a research project team;

information and software of a research project;

world experience of innovative forms introduction within research projects;

implementation of research projects in engineering schools and competitions for startups;

choice of other priority forms of research projects implementation.

Fourth, modern research is conducted based on information databases and knowledge bases developed in other teams. Such knowledge and information is disseminated on a financial basis or free of charge. In the world of science, scientific societies of the corporate type have been formed, the activities of which are aimed exclusively at creating a database of information or knowledge (indices, databases, ratings). In the monograph, M. Poliakov states that “the knowledge base is a specially organized set of data that characterize a particular subject area, and the mechanism of their processing (according to certain rules) to obtain analytical results. Knowledge

bases, one way or another, provide a certain structure of data, structuring of problem areas, experience of experts, formalization of the task, etc. [10, p. 60]. In one form or another, knowledge databases existed at all stages of civilizational development of humankind. However, the distinctive feature of modern knowledge databases is that they are direct links in the process of creating new value for high-tech goods and services;

Fifth, knowledge is generated by analyzing the accumulated scientific experience not only by using databases, but also by improving the methods and forms of such use. This once again confirms the social characteristics of knowledge. The social interaction of participants in the process of knowledge generation is becoming more extensive. In modern science, the generation of knowledge is based on increasingly complex social interaction. The subjects of such interaction are individual scientists, informal creative teams (for example, scientific schools), organized formal creative teams, scientific and educational institutions, private high-tech corporations, etc.

If to analyze the problem from another point of view, it is advisable to identify changes in the scale and forms of knowledge consumption. The scale of knowledge consumption has increased due to the growth of the economy and the processes of economic globalization. This process is also due to the changes in the structure of consumption. Nowadays, the share of consumption of services is growing.

The forms of knowledge consumption are changing. Large corporations and universities are both consumers and generators of knowledge. At the same time, corporations consume knowledge in all sectors of the economy – regardless of their level of technology. The only difference is the scale of consumption. In addition, there appear specialized corporations the activities of which are aimed at generating knowledge. Such corporations are not affiliated to high-tech industrial corporations, but already operate in a purely scientific, research market and sell ready-made knowledge. They are large organizations with complex social interaction within. In his monograph, M. Poliakov notes, “groups (communities) that use knowledge are based on a certain level of freedom of interaction, exchange of ideas and activities, on

common values, interests, organizational forms, which is also the result of social organization. Given that the use of knowledge is a collective process, it requires ways to formalize knowledge, means of communication and knowledge transfer" [10, p. 43]. Thus, the author focuses not on an individual scientist, but on the group, the team. He emphasizes the strengthening of the process of collective nature of scientific research.

Freedom of interaction, common values, interests, and the collective nature of the creative process lead to the strengthening of the social function of the knowledge economy. In the monograph, M. Poliakov identifies the factors of determining the essence of the knowledge economy, among which we can distinguish the determinants of market-technological nature and evolutionary-social nature. The former include competitive, technological and resource factors, the latter include political, economic, social and historical factors.

Technological determinants of the knowledge economy are understood as the use of advanced technologies and change in the nature of production and organization of the society. The importance of technological factors is constantly growing; competitive factors take into account changes in the nature and methods of competition, the development of competitive relations and the transformation of knowledge into a source of advantage, resource factors include human capital and technology; political-economic determinants are seen as conditions and parameters of objective knowledge that form the level of the development of production, which is characterized by an increase in knowledge; social factors determine the importance of development and effective use of human potential, creating conditions for intellectual and creative work; historical determinants are understood as the highest stage of the development of the economy and society, which corresponds to a better productive system, forms of economic organization, social relations and institutions. Figure 1.2 shows the ontological determinants of the knowledge economy, among which there are purely social determinants, as well as historical determinants that include the option of improving social institutions. It can be concluded that in the theoretical concept of M. Poliakov, a significant place is given to the social determinants of the

knowledge economy.

In his work, M. Poliakov states that social relations, the social orientation of the established industrial relations do not meet the rapidly changing requirements of the knowledge economy. Among the social determinants of the knowledge economy, the scientist identifies the following:

humanization, increasing attention to a human being and society;

development of certain social groups, such as scientists;

dominance or equality of social groups;

achievement of a high level of freedom of public relations, economic freedom, creativity, activity, experimentation;

emergence of new forms of social organization in which people can unite and interact for profit;

development of social organizations independent of the central government;

development of the informal sector of education, educational services;

development of the space of social communications;

strengthening of the role of communities, development of territorial and network communities as opposed to the state and corporations;

change of the economic culture, including in terms of knowledge acquisition, use of technologies and development of innovations;

individualization, autonomy of an individual, emphasis on increasing independence, responsibility;

emergence of special requirements for power (knowledge economy as a political and economic model) [10, p. 81 – 82].

From the given social determinants, we can see two approaches to their definition. The first approach is social relations and social influence on a particular creative personality of a researcher, granting him/her rights, freedoms, providing conditions for scientific and creative activities, appropriate sufficient material and financial support. Such determinants include humanization, increasing attention to an individual and society, development of certain social groups, such as scientists, individualization, autonomy of an individual, emphasis on increasing independence,

responsibility, achievement of a high level of freedom of public relations, economic freedom, creativity, activity, and experimentation.

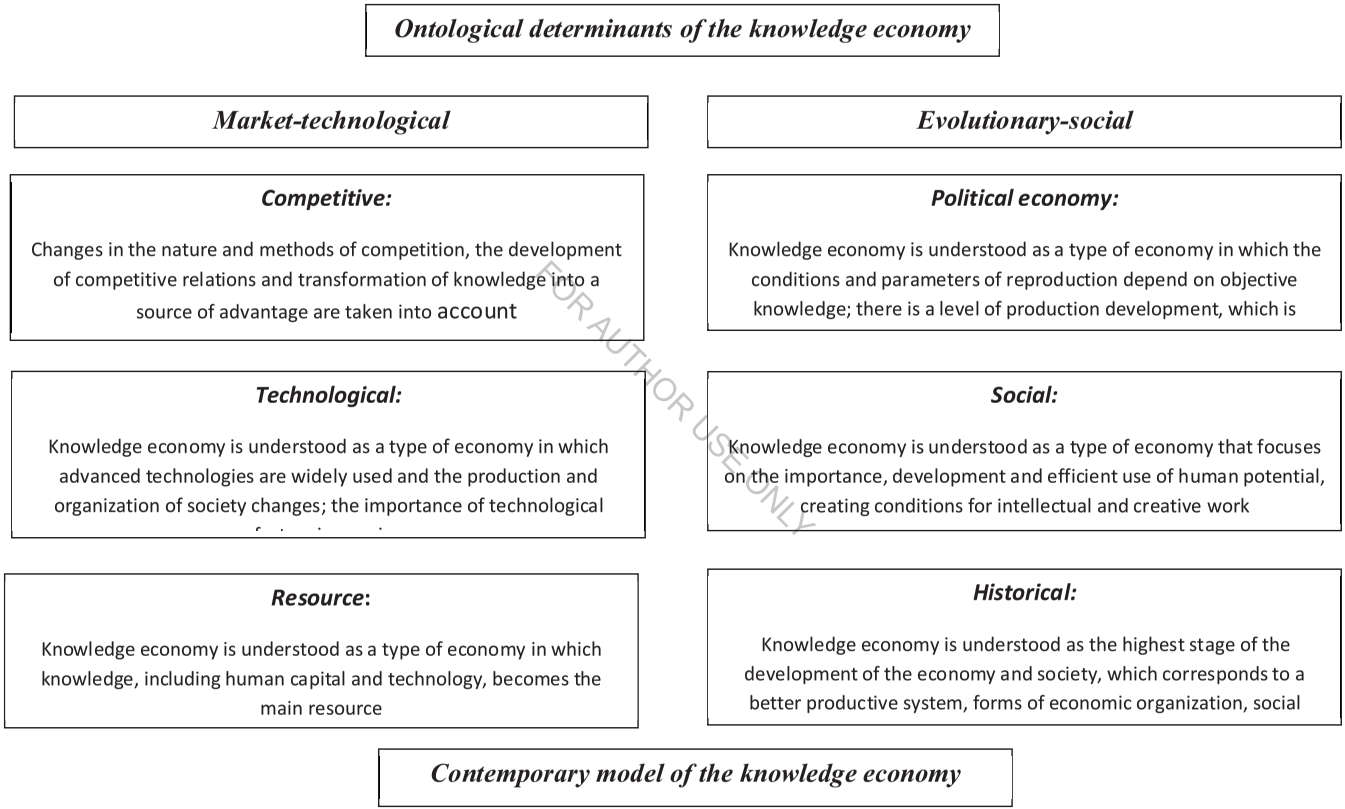

Fig. 1.2. Factors of determining the essence of the knowledge economy [developed based on source 10]

The second approach is social relations and social influence at the collective, social level. Such determinants include: dominance or equality of social, scientific groups, emergence of new forms of social organization in which people can unite and interact for profit, development of social organizations independent of central government, development of the informal education sector, educational services, development of the space of social communications, strengthening of the role of communities, development of territorial and network communities as opposed to the state and corporations, change of the economic culture, including in terms of knowledge acquisition, use of technologies and development of innovations, emergence of special requirements for power when integrated into political structures.

The analysis of the research conducted by M. Poliakov allows concluding that his scientific concept of shaping the global landscape of the knowledge economy contains a number of important social determinants for the activity of scientists and research teams.

The services sector is developing rapidly and is based on high technologies and information systems (services). In the practice of the development of individual countries and regions, which are defined as post-industrial, we can observe trends of the transfer of large production capacities outside these countries and regions. This is especially true for the industries that are not environmentally friendly, and sometimes harmful to the environment and human health. Such statistical information is difficult to access and is calculated with a long delay.

M. Poliakov conducted a thorough scientific research on the development of the knowledge economy. The main postulates of the scientific approach to the knowledge economy as a civilizational aspect of general post-industrial development in its theoretical interpretation are the same for both the post-industrial theory and the knowledge economy; however, the author sees some methodological differences.

The main prerequisites for social interaction in the process of generating

knowledge are as follows:

first, a scientist who, in the early days of human development, generated knowledge, had to rely on the accumulated empirical experience, and one generation of people was not enough to accumulate such experience.

second, modern scientific research is conducted in large research teams and breakthroughs in scientific and technological development are possible with the cooperation of creative innovators with other colleagues in the team.

third, modern research projects are based on formalized systemic organizational and preparatory solutions.

fourth, modern research is conducted based on the information and knowledge databases developed by other teams.

fifth, knowledge is generated by analyzing the accumulated scientific experience not only by using databases, but also by improving the methods and forms of such use and social interaction in the process of such use.

In his work, M. Poliakov states that social relations, social orientation of the established industrial relations do not meet the rapidly changing requirements for the knowledge economy. The scientist emphasizes the importance of certain social components of the knowledge economy.

In the monograph, M. Poliakov defines the essence of the ontological determinants of the knowledge economy, among which we can distinguish the determinants of market-technological nature and evolutionary-social nature. The former include competitive, technological and resource factors, the latter include political, economic, social and historical factors.

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CHAPTER 2
THE USE OF INTELLECTUAL METHODS TO IMPROVE OPERATION OF THE TRANSPORT SECTOR

2.1. Assessment of the condition and prospects of transport industry development in Ukraine based on the linear trend

The transport sector is one of the basic sectors of the economy; it has a well-developed network of highways, cargo customs posts and terminals, which creates the necessary conditions to meet the needs of transport users in providing transport services and business development. Today, the motor transport industry as a whole meets only the basic needs of the population and the economy in transportation by volume, but not by quality. As a result, the volume of cargo transportation is not stable and periodically decreases (Fig. 2.1)

The current state of the motor transport industry does not fully meet the requirements of the effective implementation of Ukraine's European integration course and the integration of the national transport network into the Trans-European Transport Network.

In addition to the lack of quality transportation, other equally important factors suspend the development of transport. General problems of road transport that need to be solved include [1]:

- insufficient level of competition in the transport services market and non-compliance with European requirements for access to the transport services market;
- imperfect tariff policy in the field of transport services;
- low speed of door-to-door delivery of goods and in due time;
- problematic places in transport infrastructure.

Particular attention should be paid to the domestic transportation, as it suffer the most due to the lack of necessary public funding.

Domestic transportation of goods includes their transportation between points of departure and destination located in Ukraine, and a set of ancillary operations related to this transportation, as well as technological transportation of goods carried out within one production facility without entering the highways of the general use [2]. Therefore, in order to identify possible improvements in the situation with domestic transportation, we will analyze the situation and calculate the trend of transportation volume for the coming years.

Figure 2.1 shows the dynamics of changes in the volume of goods transported by road transport in the period 2015-2019.

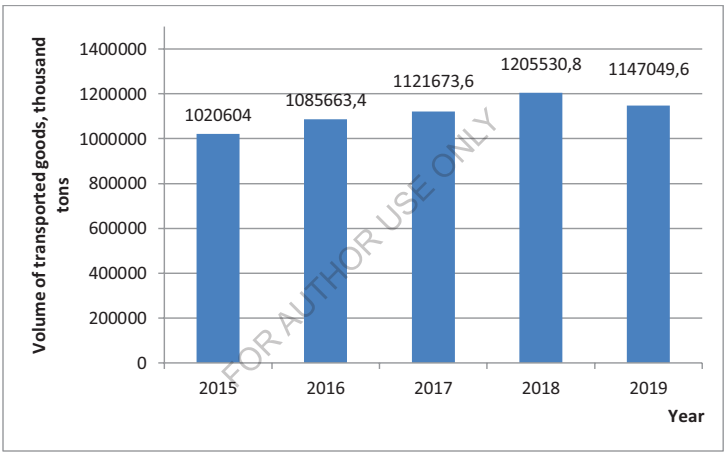

Fig. 2.1. Dynamics of changes in the volume of goods transported by road transport in the period 2015-2019 (developed by authors according to [3]).

To predict the volume of transported goods, it is necessary to choose a mathematical equation that most accurately reflects the dependence of values. First, it is needed to build a graph of the dependence of the transportation volume by year (Fig. 2.2). To build graphs, we use the data from the State Statistics Service [3].

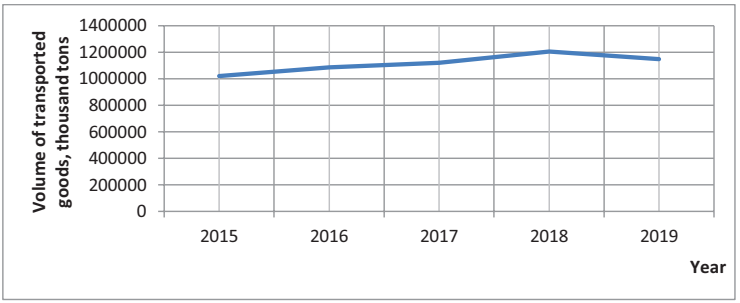

Fig. 2.2. Dynamics of changes in the volume of goods transported by road transport in the period 2015-2019 (developed by authors according to [3]).

The graph (Fig. 2.2) shows that the curve is most similar to the straight line (with small deviations), so for further calculations we will use the linear regression equation. The equation of the line has the following form:

$$y_x = a + bx, \tag{2.1}$$

where y_x – volume of transported goods;

x – time period (2015 - 2019);

a – volume of transported goods at zero period;

b – annual increase.

Finding parameters a and b is based on the least squares alignment, which leads to a system of two linear equations with two variables:

$$\begin{cases} na + b\Sigma x = \Sigma y \\ a\Sigma x + b\Sigma x^2 = \Sigma xy \end{cases} \tag{2.2}$$

Solving this equation, we find:

$$a = \frac{\Sigma y \Sigma x^2 - \Sigma xy \Sigma x}{n\Sigma x^2 - \Sigma x \Sigma x}; \tag{2.3}$$

$$b = \frac{n\Sigma xy - \Sigma y \Sigma x}{n\Sigma x^2 - \Sigma x \Sigma x}. \tag{2.4}$$

The system can be simplified to make it easier to find parameters a and b. To do this, the time countdown should be entered so that the sum of the time indicators of the series (Σx) was zero. In our case, to provide Σx=0, it is necessary to put the following coefficients in column 3 (Table 2): -2, -1, 0, 1, 2.

If the coefficients of the time series are numbered this way, then equations (3) and (4) are significantly simplified:

$$a = \frac{\Sigma y}{n}; \tag{2.5}$$

$$b = \frac{\Sigma xy}{\Sigma x^2}. \tag{2.6}$$

Let us present the problem in the form of a time series (Table 2.1).

Table 2.1

Time series of the volume of transported goods

Year	2015	2016	2017	2018	2019
Volume of transported goods, Q, thousand tons	1020604.0	1085663.4	1121673.6	1205530.8	1147049.6

According to the given time series, we develop Table 2.2 for further calculations.

Table 2.2

Calculation of the parameters of the equation of the line for forecasting

Year	Q=y	x	x^2	xy	$y_x = a + bx$
1	2	3	4	5	6
2015	1020604.0	-2	4	-2041208	1041552.6
2016	1085663.4	-1	1	-1085663	1078828.4
2017	1121673.6	0	0	0	1116104.3
2018	1205530.8	1	1	1205531	1153380.1
2019	1147049.6	2	4	2294099	1190656.0
Total	5580521.4	0	10	372758.6	5580521.4
2020		3	9		1227931.9
2021		4	16		1265207.7
2022		5	25		1302483.6
2023		6	36		1339759.4

2024		7	49		1377035.3

We substitute the obtained values in formulas (2.5), (2.6) and obtain:

$$a = \frac{\Sigma y}{n} = \frac{5580521.4}{5} = 1116104.3;$$

$$b = \frac{\Sigma xy}{\Sigma x^2} = \frac{372758.6}{10} = 37275.9.$$

The equation of the line will look like this:

$$y_x = 1116104.3 + 37275.9x.$$

After performing the calculations, we can conclude that the comparison of columns 2 and 6 (Table 2.2) for each year does not show deviations of the calculated levels from the actual ones, which confirms the correctness of the choice of the mathematical equation.

To develop a linear trend in the volume of transported goods in the period 2020 - 2024 in column 3 (Table 2.2), we continue to fill in the coefficients: 3, 4, 5, 6, 7. Using the already found equation of the line, we complete the calculations, substituting the required values. As a result, we obtain the following values (Table 2.3).

Table 2.3

The results of the trend calculations

Year	Actual values	Calculated values	Forecasted values
2015	1020604.0	1041552.6	
2016	1085663.4	1078828.4	
2017	1121673.6	1116104.3	
2018	1205530.8	1153380.1	
2019	1147049.6	1190656.0	
2020			1227931.9
2021			1265207.7
2022			1302483.6

2023			1339759.4
2024			1377035.3

Based on the received actual, calculated and forecasted values (Table 3), we build the graph of the dependence of the volume of the transported goods per year (Fig. 2.3).

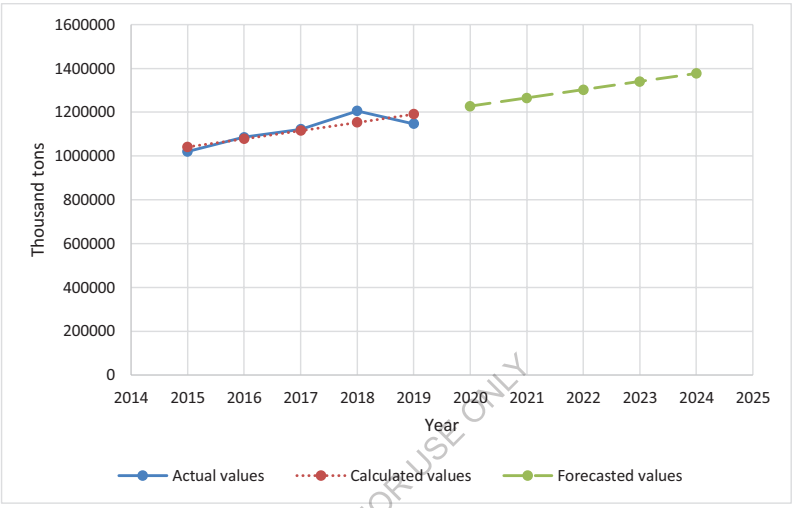

Fig. 2.3. Dynamics of changes in the volume of goods transported by road transport in the period 2015-2024.

As it can be seen from the graph, the volume of transported goods will increase. However, this will happen only under certain conditions, namely: it is necessary to increase the efficiency and competitiveness of the transport sector, to improve the legal mechanism of public-private partnership, to strengthen cooperation between public and private sector, public and local authorities, to carry out necessary reforms, including the introduction of decentralization in the transport sector.

2.2. Development of the information infrastructure of a transport company using graph theory

Effective operation of modern road transport is impossible without the widespread use of the full range of information technology. Information flows between the objects of the road transport system form both feedback, which carries information about the current state of road transport objects, and direct communication, which provides the transfer of management effects [6]. The quality and timeliness of information received in the forward and reverse directions depend on the quality of management of individual objects of the transport system, as well as the possibility of its coordinated operation in order to fully meet society's demands for the transportation of goods and passengers. The technologies used at all stages of receiving, storing, processing and transmitting information must fully ensure the timeliness and high quality of the information support in management decisions at all levels of the transport system [7].

In their operation, transport companies are faced with the need to solve problems of the use of information technology in their activities and to provide information processes in all transport structures. When considering the technologies of telecommunication interaction in road transport, a special place is given to the relevant issues of organization of wireless communication, as well as the use of resources and opportunities of the global Internet network. Technologies for automatic identification of vehicles and equipment are widely used to increase the efficiency of transport and logistics processes. The means of telemetry on vehicles allow timely detection and prompt elimination of numerous types of emergencies, as well as optimize transportation processes, based on the situation on the transport network and the state of a particular vehicle. Particular attention in modern road transport systems is paid to promising issues of automatic vehicle control, carried out both locally and by tele mechanics. Since the road transport

system is geographically distributed, a modern specialist must master methods of spatial analysis based on geographic information technology. The present stage of development of transport enterprises requires considering the issues of effective organization and multidimensional analysis of large data sets, which are relevant and important in information protection technology [8].

Let us consider the activities of the new transport company "Velocity", which has just constructed its facilities and is preparing for operation. The company is located in the city of Rivne and begins operation in accordance with the current legislation of Ukraine [9, 10, 11]. The transport company plans to transport goods within Ukraine and to provide the following services:

– road freightage;

– freight forwarding;

– cargo tracking;

– cargo insurance;

– calculations for the supply of goods;

– unloading and loading of cargoes.

The key to the success of a transport company is the presence of competent professionals, experienced drivers and dedicated company managers, able in the shortest possible time to deliver freight and perform related services for any customer. The company's staff must improve their skills in a timely manner

Currently, a contract for the provision of services by the company is under development, which will allow offering potential customers (shippers) the best option for a contract for the carriage of goods, which will be repeatedly verified and agreed with the legal department of the company.

This contract will fully comply with the requirements of the Ukrainian transport and customs legislation and all international agreements and conventions; it will clearly regulate the company's obligations to a customer (shipper) regarding organization of transportation and freight forwarding.

The information infrastructure of such an enterprise usually consists of a number of independent networks: telephone network, local computing network, global network, etc.

Given the high reliability of the equipment, it is enough to have one responsible employee, who will be able to combine the main work with the additional one, in the radio relay units of company's departments. Additional work is to monitor the uninterruptible power supply of communications.

Any enterprise should have a network to transmit information. The studied company will have a network connected by e-mail and electronic document management system. We present the construction of this network in the company "Velocity", using graph theory [12]. The company will install a system of corporate e-mail and electronic document management, which will allow the transfer of information between the head office and departments. These departments include: 0 – Transportation Department; 1 – Office; 2 – Accounting Department; 3 – Planning and Economic Department; 4 – Legal Department; 5 – Mechanical department; 6 – Communications Department; 7 – Human Resources Department.

The network of possible connections between departments is shown in Figure 2.4. We need to build a communication network.

A minimum-length communication network is a shortest path tree, i.e. a set of network links that has a minimum total length and ensures the connection of all network nodes; otherwise, it is possible to get from any node to any other node.

Let us consider an algorithm for building such a network.

1) Start with any node and connect it to the nearest node. Assume that these are connected nodes, at the same time all other nodes are not connected.

2) Determine the unconnected node that is closest to one of the connected nodes. If there are several such nodes, then choose any. Add this node to the connected nodes. Continue this operation while there are unconnected nodes.

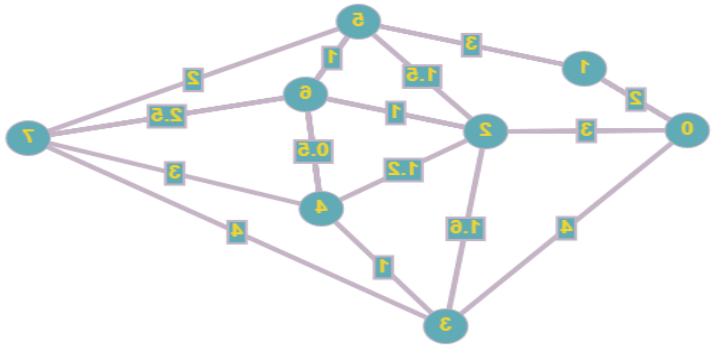

Fig. 2.4. A network of possible electronic communications between "Velocity" departments

Figure 2.4 shows the length of communications in kilometers. Let us design a communication system project that will allow providing access to the communications system for all eight departments. The solution must have the minimum possible continuous length of communications. Let us start with node 0. The closest to it, as we see, is node 1, located at a distance of two kilometers. We assume that nodes 0 and 1 are connected. Thus, we have the following initial network: (Figure 2.5).

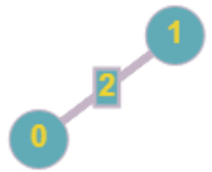

Fig. 2.5. Communication between the Transportation Department and the "Velocity" Office

The closest unconnected nodes to one of the connected nodes 0 and 1 are nodes 2 and 5. We choose one of them, for example, node 2. Now, we consider nodes 0, 1, 2 connected (Fig. 2.6).

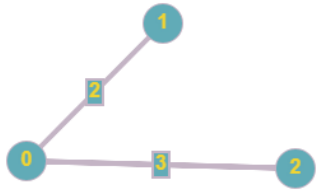

Fig. 2.6. Communication between “Velocity” Transport Department, Office and Accounting Department

Next, we find the nearest unconnected node to the nodes 0, 1, 2. This node will be node 6, which is located at a distance of 1 km from node 2. Now, we consider nodes 0, 1, 2, 6 connected (Figure 2.7).

Fig. 2.7. Communication between “Velocity” Transport Department, Office, Accounting Department and Communications Department

In the next step, we need to find the nearest unconnected node in relation to nodes 0, 1, 2, 6. This is node 4, located at a distance of 0.5 km from node 6. Now, we consider nodes 0, 1, 2, 6, 4 connected. Figure 2.8 shows this.

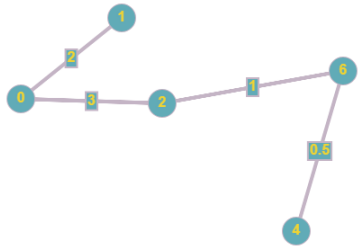

Fig. 2.8. Communication between “Velocity” Transport Department, Office, Accounting Department, Communications Department and Legal Department

Next, we find the nearest unconnected node in relation to nodes 0, 1, 2, 6, 4. These nodes will be nodes 3 and 5, which are located at a distance of 1 km from nodes 4 and 6, respectively. We select any of them, for example, node 3. Now, we consider nodes 0, 1, 2, 6, 4, 3 connected (Figure 2.9).

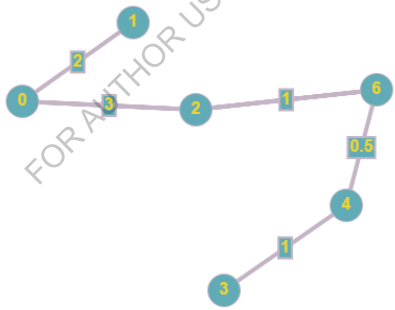

Fig. 2.9. Communication between “Velocity” Transport Department, Office, Accounting Department, Communications Department, Legal Department and Planning and Economic Department

Next, we find the closest unconnected node in relation to the connected nodes 0, 1, 2, 6, 4, 3. This is node 5, located at a distance of 1 km from node 6. Figure 2.10 shows the connected nodes 0, 1, 2, 6, 4, 3, 5.

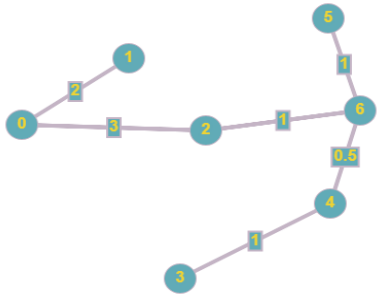

Fig. 2.10. Communication between “Velocity” Transport Department, Office, Accounting Department, Communications Department, Legal Department, Planning and Economic Department, and Mechanical Department

Then, we find the best connection for node 7. It will be its connection with node 5 (the distance is 5 km). As a result, a shortest path tree is constructed. Its length is the sum of the links distances 2 + 3 + 1 + 1 + 0.5 + 1 + 2 = 10.5 (km). Thus, communication between “Velocity” departments will take place according to the presented scheme (Figure 2.11).

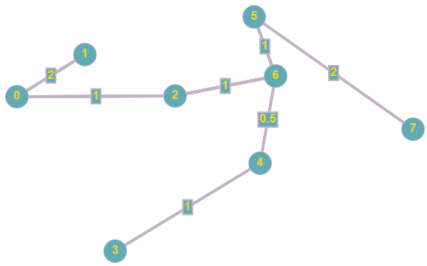

Fig. 2.11. The scheme of the optimum communication links between “Velocity” departments

The presented scheme optimizes the work of the company's departments due to the increased speed of communication.

2.3. Regression dependence research on the road transportation in Ukraine

Road transport in Ukraine is a service link for the entire national economy. The position of other industries largely depends on its condition, because other sectors of the Ukrainian economy are consumers of transport services. Transport plays an important role in the development of the economy of any state. It ensures the interaction of the main components of the economy and the integrity of the entire economic complex. At the same time, transport ensures the implementation of international economic and political ties.

Due to the activity of the transport sector of the economy in any country it is possible to achieve maximum employment, rational use of all types of resources, movement of manufactured products and delivery of necessary imported goods. The level and quality of the transport system development largely determine the success and level of the country's development. Even within one state, territorial differences in the development of the transport sector affect the economic disparity in the territorial development of regions. For example, the transport systems of Eastern and Western Ukraine differ. Therefore, the successful further development of the country's economy requires comprehensive development of the entire transport sector.

Each type of transport has its advantages and disadvantages. These are maneuverability and dependence on weather conditions, comfort and speed of movement, cost and safety. By developing the entire transport system as a complex entity, it is possible to combine the advantages of each mode of transport and compensate for its shortcomings at the expense of other types. The integrated

transport system ensures the coordinated development and operation of all modes of transport in order to best meet transportation needs at minimum cost.

Ukraine is actively involved in the world social and economic processes. The country became a member of the World Trade Organization and has associate membership in the European Union. Transport, which is an infrastructure sector, must develop at a faster pace in order to promote the country's rapid economic and social growth and its participation in the international division of labor. In order to increase the efficiency of the transport system, it is necessary to comprehensively update and modernize transport, which will include a set of measures for regulatory and legal support and the creation of a favorable investment climate, involving budgetary and non-budgetary investment. The purpose of such a strategy is to identify key issues, goals, principles and priorities for the development of Ukraine's transport system in terms of national challenges. The implementation of the transport strategy will contribute to the intensive increase in the efficiency of the transport system, sustainable development of the economy and well-being of Ukrainians.

A necessary condition for the positive development of a road transport company is its economic security, protection from the effects of destabilizing factors from both internal and external environment. This may ensure high efficiency of the economic activity, which contributes to the company development [15].

The article [16] provides a comprehensive analysis of the condition and problems of the transport system development in Ukraine in the light of threats and risks associated with crisis processes. The article pays particular attention to optimizing the functioning of the transport system using potential opportunities and competitive advantages. The authors note that today Ukraine differs from other countries because a significant number of its cities and towns are located on the traditional transport and communication routes of Eurasia. The state has a rather high coefficient of transitivity (transport attractiveness), but this indicator is

potential and can be realized only in the real competitive environment involving other countries. Targeted consideration of potential opportunities will assist Ukraine in achieving a new level of development in the implementation of its main priorities, including in the field of transport services.

A. Nasution, K. Erwin and L. Bartuska [17] studied various options for public transport, based on the development of information technology, which developed rapidly at the beginning of this decade. Transport is an important element and serves as a source of vitality and economic, social and political mobility of the population, which grows together and follows the processes taking place in various fields and industries. Many transport companies offer their service trying to attract passengers and customers. The information technology development improves public transport in terms of access and cost, and ordering services by customers. Go Car (Go jek) and Grab are companies that use virtual programs to facilitate ordering transportation services. Using analytical tools, namely, transaction costs the authors assess business effectiveness of the institutional design of the organization. The higher the costs incurred in economic activities, the more inefficient the institutional design is. Conversely, lower costs incurred in economic activities mean that institutional efficiency is high.

In [18], J. Asturias provides quantitative trade models used to assess the effects of changes in transport modeling policies. This document expands Armington standard trade model to include an oligopolistically competitive transportation industry in which shippers endogenously choose transportation technology. The author collected detailed data on the container shipping industry to calibrate the model parameters. He then conducted quantitative experiments in which there is a symmetrical increase in tariffs. On average, changes in transport costs account for almost half of changes in welfare. These findings suggest that the endogenous character of transport costs is an important mechanism for determining the impact of such policy changes on welfare.

After analyzing the works of well-known Ukrainian and foreign scientists on the transport sector, it is necessary to investigate its forecast indicators and the relationship with the main indicator of economic development – GDP.

In Ukraine, as Table 2.4 shows, the use of road transport by passengers is declining, and the forecast for the passenger transportation is disappointing (Figure 2.12).

Table 2.4

Dynamics of passenger transportation using road transport in Ukraine (Developed based on [20])

Year	Passenger transportation (persons)
1996	3304600
1997	2512147.2
1998	2403424.6
1999	2501707.5
2000	2557214.6
2001	2722001,6
2002	3069136.3
2003	3297504.5
2004	3720326.4
2005	3836514.5
2006	3987982
2007	4173033.7
2008	4369125.5
2009	4014035.2
2010	3726288.6

2011	3611829.9
2012	3450173.1
2013	3343569.5
2014	2913318.1
2015	2250345.3
2016	2024892.9
2017	2019324.9
2018	1906852.1
2019	1804929.3
2020	1083872.7

Reductions in passenger transportation due to the hostilities in the east of Ukraine have a major impact on the negative dynamics of passenger traffic. In order to overcome the negative trend, it is necessary both to make changes to the Ukrainian legislation and to cooperate with foreign countries in the field of road transport. Some steps have already been taken in this direction. For example, the Cabinet of Ministers of Ukraine adopted the Resolution dated 07.02.2018 № 180 "On amendments to the bidding procedure for passenger transportation on public bus routes", according to which "bidding procedure for interregional bus routes will now be held based on the applications" [21]. In addition, carriers that have upgraded their vehicles are given the opportunity to renew their permits.

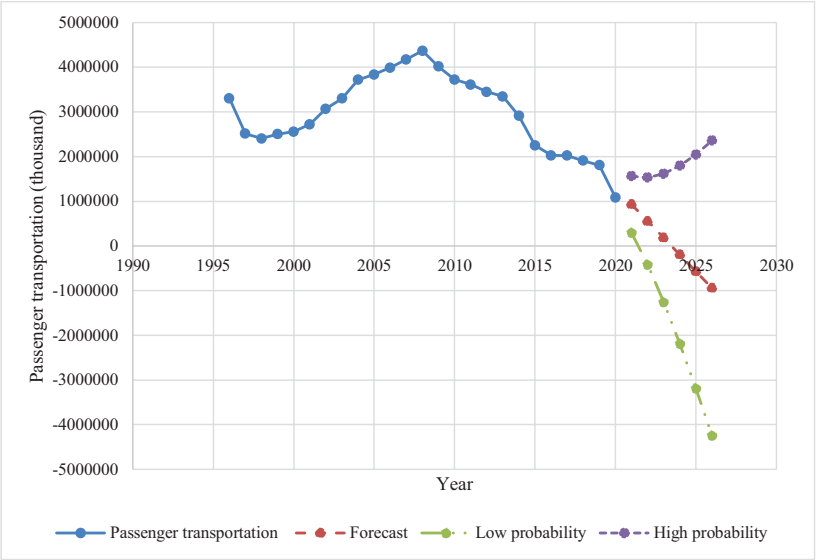

Fig. 2.12. Forecast for passenger transportation dynamics in Ukraine. Source: developed by the authors using data [20]

To improve the situation in the transport sector, certain provisions regarding transport declared in the Association Agreement between the EU and Ukraine are being implemented now. According to Article 368 of the Association Agreement, transport will be gradually updated and restructured, while current policies and standards will be adopted to the existing documents in the EU.

The development of concession roads in Ukraine is a positive step in this direction. This will increase the passenger flow of the road transport. The convenience of booking and purchasing transport tickets is also improving. It should be noted that in 2020, rail passengers bought 66% of tickets online [22]. The Ukrainian parliament is currently considering a bill on public-private partnership in the road sector, which provides for the involvement of private investors in the construction of highways. The payback of the projects is planned

for 20-30 years after the end of construction and will depend on the quality of the constructed and further maintained road. Roads will not be tolled for citizens. At the same time, fines may be levied for poor road maintenance and non-compliance with the accepted standards.

Regarding road freight transportation, the situation is better (Table 2.5).

Table 2.5

Dynamics of freight road transportation in Ukraine (developed based on [5])

Year	Freight road transportation (thousand tons)
1996	1254540.2
1997	1249866.6
1998	1081326.2
1999	955329.1
2000	938916.1
2001	977268.8
2002	947323,8
2003	943283
2004	1027396.3
2005	1120715.3
2006	1167199.7
2007	1255225.3
2008	1266598.1
2009	1068857.9
2010	1168218.8
2011	1252390.3
2012	1259697.7

2013	1260767.5
2014	1131312.7
2015	1020604
2016	1085663.4
2017	1121673.6
2018	1205530.8
2019	1147049.6
2020	1232391.9

As Figure 2.13 shows, a small increase is forecasted in this sector.

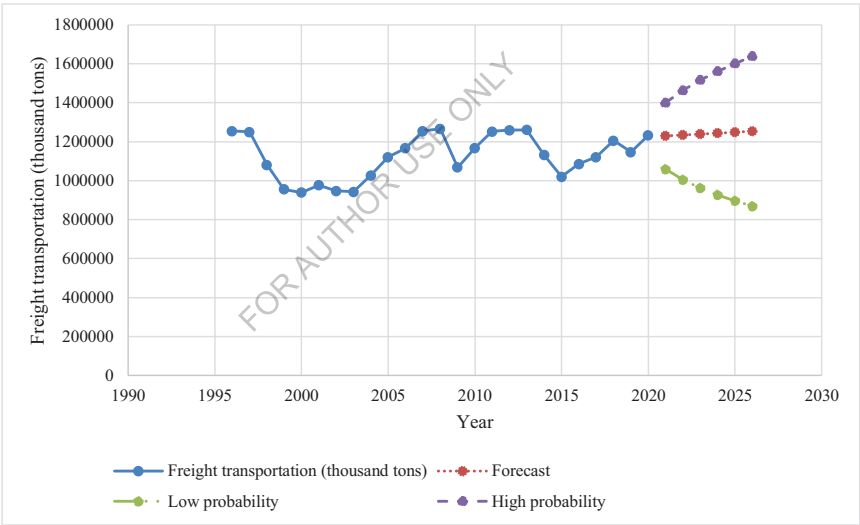

Fig. 2.13. Forecast for freight road transportation in Ukraine. Source: developed by authors using the data from [20]

The slow growth rate is due to the fact that many carriers (about 30%) in Ukraine are still in the shadows. Thus, payment for transportation is made in many

cases in cash. The main contribution to this growth is made by such industries as construction, food, and processing. Container transportation make a significant share in the general amount. Despite the high competitiveness of the road transport market, carrier companies are poorly organized, and there is a lack of effective associations of these companies. The exception here is the Association of International Carriers of Ukraine (ASMAP).

One of the problem issues in the functioning of the trucking market was dimensional and weight control on the roads. It can be stated that a certain part of truckers obeys the rules of this control, but most of them ignore these rules. Most violations of dimensional and weight control are found in the agricultural sector, where about 60-65% of products are transported with violations of dimensional and weight control.

The imperfection of the Ukrainian legislation also hinders the development of the road transport industry. Carrier companies are overloaded with taxes. In addition, energy saving in Ukraine is at a very low level, which leads to the huge costs of resources for transport.

The development of transport is also negatively affected by the depreciation of fixed assets of infrastructure, which poses a risk of accidents. Due to the low quality of transport infrastructure, there are additional unproductive costs that slow down the GDP growth. The positive dynamics of road freight transportation is due to the fact that more and more goods are redistributed from rail to road [23].

Let us investigate whether there is a connection between Ukraine's GDP and road transportation. We take freight road transportation as a basis for calculations. The linear connection is very weak (formula (2.7)).

$$y = 0,3346x - 272037 \quad (2.7)$$

The coefficient of determination is only 0.5234.

Let us try to find out other types of dependencies. The most acceptable of these is polynomial dependence.

Consider we have two series of observations x_i (independent variable) and y_i (dependent variable), $i = \overline{1,n}$. The equation of the polynomial has the form:

$$y = \sum_{j=0}^{k} b_j x^j, \tag{2.8}$$

where b_j – parameters of this polynomial. We find with the least squares method parameters b_j of this regression. The least squares method is based on minimizing the following:

$$S = \sum_{i=1}^{n} (\hat{y}_i - y_i)^2 \to min, \tag{2.9}$$

where $\hat{y}_i$ is a theoretical value, which is the value of polynomial (2) at points x_i. Substituting (2.8) into (2.9), we obtain:

$$S = \sum_{i=1}^{n} \left(\sum_{j=1}^{k} b_j x_i^j - y_i \right)^2 \to min \tag{2.10}$$

Based on the necessary condition of the extremum of the function $(k+1)$ of the variables $S = S(b_0, b_1, \ldots b_k)$ we equate to zero its partial derivatives, i.e.

$$S'_{b_p} = 2 \sum_{i=1}^{n} x_i^p \left(\sum_{j=1}^{k} b_i x_i^j - y_i \right), p = \overline{0.k} \tag{2.11}$$

Dividing the left and right parts of each equation by 2, we find the second sum:

$$\sum_{i=1}^{n} x_i^p \left(b_0 + b_1 x_i + b_2 x_i^2 + \cdots + b_k x_i^k \right) - \sum_{i=1}^{n} x_i^p y_i = o, \; p = \overline{0,k} \tag{2.12}$$

Opening brackets, we move in each *p*-th expression the last summand from $\boldsymbol{y_i}$ to the right and divide both parts by *n*. We obtain $(\boldsymbol{k+1})$ expressions that form a system of linear equations with respect to $\boldsymbol{b_p}$. It looks as follows:

$$\begin{cases} b_0 + b_1\overline{x} + b_2\overline{x^2} + \cdots + b_k\overline{x^k} = \overline{y} \\ b_0\overline{x} + b_1\overline{x^2} + b_2\overline{x^3} + \cdots + b_k\overline{x^{k+1}} = \overline{xy} \\ b_0\overline{x^2} + b_1\overline{x^3} + b_2\overline{x^4} + \cdots + b_k\overline{x^{k+2}} = \overline{x^2y} \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ b_0\overline{x^k} + b_1\overline{x^{k+1}} + b_2\overline{x^{k+2}} + \cdots + b_k\overline{x^{2k}} = \overline{x^ky} \end{cases} \quad (2.13)$$

To solve the system of equations, we can use one of the numerical methods in modeling the trend using the computer. The result of the calculation will be quite accurate. Let us solve the system of equations for finding the polynomial of the fifth degree.

$$\begin{cases} b_0 + b_1\overline{x} + b_2\overline{x^2} + b_3\overline{x^3} + b_4\overline{x^4} + b_5\overline{x^5} = \overline{y} \\ b_0\overline{x} + b_1\overline{x^2} + b_2\overline{x^3} + b_3\overline{x^4} + b_4\overline{x^5} + b_5\overline{x^6} = \overline{xy} \\ b_0\overline{x^2} + b_1\overline{x^3} + b_2\overline{x^4} + b_3\overline{x^5} + b_4\overline{x^6} + b_5\overline{x^7} = \overline{x^2y} \\ b_0\overline{x^3} + b_1\overline{x^4} + b_2\overline{x^5} + b_3\overline{x^6} + b_4\overline{x^7} + b_5\overline{x^8} = \overline{x^3y} \\ b_0\overline{x^4} + b_1\overline{x^5} + b_2\overline{x^6} + b_3\overline{x^7} + b_4\overline{x^8} + b_5\overline{x^9} = \overline{x^4y} \\ b_0\overline{x^5} + b_1\overline{x^6} + b_2\overline{x^7} + b_3\overline{x^8} + b_4\overline{x^9} + b_5\overline{x^{10}} = \overline{x^5y} \end{cases} \quad (2.14)$$

.

The system of equations is solved using Gaussian method. Gaussian method is based on the idea of successive elimination of variables one at a time until there is only one equation with one variable on the left. This equation is then solved with respect to a single variable. Thus, the system of equations leads to a triangular (echelon) form. To do this, among the elements of the first column of the matrix, we choose a non-zero (and often the maximum) element and move it to the uppermost position by permuting rows. Then, we normalize all equations dividing by the coefficient a_{i1} of the matrix of the equation with respect to (b_i), where *i*- is the column number. Then, we obtain:

$$\begin{cases} b_0 + b_1\overline{x} + b_2\overline{x^2} + b_3\overline{x^3} + b_4\overline{x^4} + b_5\overline{x^5} = \overline{y} \\ b_0 + b_1\dfrac{\overline{x^2}}{\overline{x}} + b_2\dfrac{\overline{x^3}}{\overline{x}} + b_3\dfrac{\overline{x^4}}{\overline{x}} + b_4\dfrac{\overline{x^5}}{\overline{x}} + b_5\dfrac{\overline{x^6}}{\overline{x}} = \dfrac{\overline{xy}}{\overline{x}} \\ b_0 + b_1\dfrac{\overline{x^3}}{\overline{x^2}} + b_2\dfrac{\overline{x^4}}{\overline{x^2}} + b_3\dfrac{\overline{x^5}}{\overline{x^2}} + b_4\dfrac{\overline{x^6}}{\overline{x^2}} + b_5\dfrac{\overline{x^7}}{\overline{x^2}} = \dfrac{\overline{x^2y}}{\overline{x^2}} \\ b_0 + b_1\dfrac{\overline{x^4}}{\overline{x^3}} + b_2\dfrac{\overline{x^5}}{\overline{x^3}} + b_3\dfrac{\overline{x^6}}{\overline{x^3}} + b_4\dfrac{\overline{x^7}}{\overline{x^3}} + b_5\dfrac{\overline{x^8}}{\overline{x^3}} = \dfrac{\overline{x^3y}}{\overline{x^3}} \\ b_0 + b_1\dfrac{\overline{x^5}}{\overline{x^4}} + b_2\dfrac{\overline{x^6}}{\overline{x^4}} + b_3\dfrac{\overline{x^7}}{\overline{x^4}} + b_4\dfrac{\overline{x^8}}{\overline{x^4}} + b_5\dfrac{\overline{x^9}}{\overline{x^4}} = \dfrac{\overline{x^4y}}{\overline{x^4}} \\ b_0 + b_1\dfrac{\overline{x^6}}{\overline{x^5}} + b_2\dfrac{\overline{x^7}}{\overline{x^5}} + b_3\dfrac{\overline{x^8}}{\overline{x^5}} + b_4\dfrac{\overline{x^9}}{\overline{x^5}} + b_5\dfrac{\overline{x^{10}}}{\overline{x^5}} = \dfrac{\overline{x^5y}}{\overline{x^5}} \end{cases} \tag{2.15}$$

Then, we subtract after permutation the first received row from other rows:

$$\begin{cases} b_0 + b_1\overline{x} + b_2\overline{x^2} + b_3\overline{x^3} + b_4\overline{x^4} + b_5\overline{x^5} = \overline{y} \\ 0 + b_1\left(\dfrac{\overline{x^2}}{\overline{x}} - \overline{x}\right) + b_2\left(\dfrac{\overline{x^3}}{\overline{x}} - \overline{x^2}\right) + b_3\left(\dfrac{\overline{x^4}}{\overline{x}} - \overline{x^3}\right) + b_4\left(\dfrac{\overline{x^5}}{\overline{x}} - \overline{x^4}\right) + b_5\left(\dfrac{\overline{x^6}}{\overline{x}} - \overline{x^5}\right) = \dfrac{\overline{xy}}{\overline{x}} - \overline{y} \\ 0 + b_1\left(\dfrac{\overline{x^3}}{\overline{x^2}} - \overline{x}\right) + b_2\left(\dfrac{\overline{x^4}}{\overline{x^2}} - \overline{x^2}\right) + b_3\left(\dfrac{\overline{x^5}}{\overline{x^2}} - \overline{x^3}\right) + b_4\left(\dfrac{\overline{x^6}}{\overline{x^2}} - \overline{x^4}\right) + b_5\left(\dfrac{\overline{x^7}}{\overline{x^2}} - \overline{x^5}\right) = \dfrac{\overline{x^2y}}{\overline{x^2}} - \overline{y} \\ 0 + b_1\left(\dfrac{\overline{x^4}}{\overline{x^3}} - \overline{x}\right) + b_2\left(\dfrac{\overline{x^5}}{\overline{x^3}} - \overline{x^2}\right) + b_3\left(\dfrac{\overline{x^6}}{\overline{x^3}} - \overline{x^3}\right) + b_4\left(\dfrac{\overline{x^7}}{\overline{x^3}} - \overline{x^4}\right) + b_5\left(\dfrac{\overline{x^8}}{\overline{x^3}} - \overline{x^5}\right) = \dfrac{\overline{x^3y}}{\overline{x^3}} - \overline{y} \\ 0 + b_1\left(\dfrac{\overline{x^5}}{\overline{x^4}} - \overline{x}\right) + b_2\left(\dfrac{\overline{x^6}}{\overline{x^4}} - \overline{x^2}\right) + b_3\left(\dfrac{\overline{x^7}}{\overline{x^4}} - \overline{x^3}\right) + b_4\left(\dfrac{\overline{x^8}}{\overline{x^4}} - \overline{x^4}\right) + b_5\left(\dfrac{\overline{x^9}}{\overline{x^4}} - \overline{x^5}\right) = \dfrac{\overline{x^4y}}{\overline{x^4}} - \overline{y} \\ 0 + b_1\left(\dfrac{\overline{x^6}}{\overline{x^5}} - \overline{x}\right) + b_2\left(\dfrac{\overline{x^7}}{\overline{x^5}} - \overline{x^2}\right) + b_3\left(\dfrac{\overline{x^8}}{\overline{x^5}} - \overline{x^3}\right) + b_4\left(\dfrac{\overline{x^9}}{\overline{x^5}} - \overline{x^4}\right) + b_5\left(\dfrac{\overline{x^{10}}}{\overline{x^5}} - \overline{x^5}\right) = \dfrac{\overline{x^5y}}{\overline{x^4}} - \overline{y} \end{cases}$$

(2.16)

We obtain a new system of equations with replaced corresponding coefficients.

$$\begin{cases} b_0 + b_1a'_{11} + b_2a'_{12} + b_3a'_{13} + b_4a'_{14} + b_5a'_{15} = y'_1 \\ b_0 + b_1a'_{21} + b_2a'_{22} + b_3a'_{23} + b_4a'_{24} + b_5a'_{25} = y'_2 \\ b_0 + b_1a'_{31} + b_2a'_{32} + b_3a'_{33} + b_4a'_{34} + b_5a'_{35} = y'_3 \\ b_0 + b_1a'_{41} + b_2a'_{42} + b_3a'_{43} + b_4a'_{44} + b_5a'_{45} = y'_4 \\ b_0 + b_1a'_{51} + b_2a'_{52} + b_3a'_{53} + b_4a'_{54} + b_5a'_{55} = y'_5 \\ b_0 + b_1a'_{61} + b_2a'_{62} + b_3a'_{63} + b_4a'_{64} + b_5a'_{65} = y'_6 \end{cases} \tag{2.17}$$

After these transformations have been performed, the first row and the first column are eliminated and the specified process is continued for all subsequent equations until there is an equation with one variable:

$$\begin{cases} b_0 + b_1 a'_{11} + b_2 a'_{12} + b_3 a'_{13} + b_4 a'_{14} + b_5 a'_{15} = y'_1 \\ 0 + b_1 + b_2 a''_{22} + b_3 a''_{23} + b_4 a''_{24} + b_5 a''_{25} = y''_2 \\ 0 + 0 + b_2 + b_3 a'''_{33} + b_4 a'''_{34} + b_5 a'''_{35} = y'''_3 \\ 0 + 0 + 0 + b_3 + b_4 a''''_{44} + b_5 a''''_{45} = y''''_4 \\ 0 + 0 + 0 + 0 + b_4 + b_5 a'''''_{55} = y'''''_5 \\ 0 + 0 + 0 + 0 + 0 + b_5 = y''''''_6 \end{cases} \quad (2.18)$$

Let us now make the inverse substitution. The inverse substitution involves the substitution of the value of the variable b_5 in the previous equations:

$$\begin{gathered} b_4 = y'''''_5 - b_5 a'''''_{55} \\ b_3 = y''''_4 - b_4 a''''_{44} - b_5 a''''_{45} \\ b_2 = y'''_3 - b_3 a'''_{33} - b_4 a'''_{34} - b_5 a'''_{35} \\ b_1 = y''_2 - b_2 a''_{22} - b_3 a''_{23} - b_4 a''_{24} - b_5 a''_{25} \\ b_0 = y'_1 - b_1 a'_{11} - b_2 a'_{12} - b_3 a'_{13} - b_4 a'_{14} - b_5 a'_{15} \end{gathered} \quad (2.19)$$

Solving this system of equations using Excel, we obtain a polynomial of the fifth degree. Thus, the GDP of Ukraine is expressed through freight road transportation as follows:

$$y = 2 \times 0,1^{-21} x^5 - 0,1^{-14} x^4 + 2 \times 0,1^{-8} x^3 - 0,0248 x^2 + 13467 x - 3 \times 0,1^9 \quad (2.20)$$

Here, the coefficient of determination is more acceptable than in the case of a linear relationship ($R^2 = 0.5743$). However, the connection is still weak.

In our opinion, this is primarily due to the growing share of the shadow market in transport in Ukraine, which is why the official statistics do not record the amount of work performed on transport.

Let us identify the ways to solve the main problems of the road transport sector. This requires the following measures. First, the tax burden should be reduced. Further, special attention should be paid to international freight transportation, where partial compensation of resource costs should be introduced. In order to develop this field, the state should lobby for an increase in the quota of international transportation permits in Ukraine. There is also a need for high-quality reconstruction of transport routes, which will lead to the inevitable transit attractiveness of the country and will reduce the repair costs of domestic enterprises. The prospect of the further research is to study internal and external threats, which require introducing methods of economic security management in transport enterprises.

2.4. Application of the method of Lagrange multipliers to optimize the transportation of wood products

At present, the woodworking industry occupies an important position in the economy of Ukraine. The problem is that the issue of sales of unprocessed wood and control over its sale is not fully regulated. This shortcoming may lead to the fact that production will be left without raw material supply or will receive it in insufficient quantities. In turn, this can lead to employment reduction, loss of markets, and other negative consequences for the country's economy. Access to the shared resource should be free. At the same time, there must be competition in the woodworking market [24].

Woodworking companies are increasingly complaining about problems with the supply of resources due to the transport inconsistencies. Thus, the state forestry company declares a significant reduction in the harvesting of pine logs, but then puts them up for sale at auction at inflated starting prices.

These actions can cause millions of losses to national processing companies and make them reduce production. It should be noted that the raw material supply

of woodworking companies in Ukraine at affordable prices is considered the main factor that determines their smooth operation. If woodworking companies have quality raw materials, they will work efficiently, will have the opportunity to create new jobs, will attract investment and pay taxes.

In Ukraine, the woodworking industry has a special system of electronic accounting of wood in all forests of the State Forestry Agency, which covers almost 70% of forestry enterprises in Ukraine. It is necessary to extend this system to the forests of all forms of ownership. This will block the channels of illegal timber trafficking and possible illegal logging [24]. That is, we see improvements in this area. However, Ukrainian entrepreneurs are worried not only about the supply of raw materials, but also about how the products will be delivered to the consumer. The efficiency of product use depends on it. The task is to optimize transport costs, taking into account the preferences of wood industry producers for a particular mode of transport.

Woodworking industry has been the object of study for many researchers. In particular, I. M. Ozarkiv, I, S. Mysak, I. A. Sokolovskyi in [25], using data on the economic and natural resource potential of woodworking industries, investigated how the timber industry in Ukraine functions at the medium level. Based on the research, they identified the features of the woodworking industry, namely, analyzed cross-sectoral links and cost levels of European and domestic woodworking enterprises. They carried out the comparison of the raw material potential of the woodworking industry of the EU member states and Ukraine, and studied the structural changes in the raw material potential of the woodworking enterprises at the regional level. The authors classified the enterprises of the Western region of Ukraine according to the stages of primary and secondary wood processing. Scientists also identified key problems in the development of the woodworking industry in Ukraine and substantiated the prospects and forms of realization of woodworking potential.

This type of industry can function effectively only if the transport system of Ukraine provides proper logistics of raw materials, intermediate and final products. Many Ukrainian and foreign scientists have dealt with the problem of transportation.

M. M. Bilous and A. I. Vyhovskyi in [26] studied the current problem of improving the technology of timber transportation and analyzed ways to optimize the transportation process at all stages. They also presented results of studying the experience of timber transportation at the branch of the National University of Life and Environmental Sciences of Ukraine "Boyarska Forest Research Station'. In addition, the authors analyzed the existing technologies and technical means at forest transport enterprises.

Analyzing logging technologies, the scientists found that a single-stage transport scheme is used to transport about 80% of products. This scheme works efficiently for a short distance transportation. In addition, about 20% of timber is transported using a multi-stage transport scheme. In general, with multi-stage transportation, the cost of transporting 1 m^3 of wood is reduced by 28%. The economic effect is achieved by reducing the average distance of timber transportation and transfer of fixed costs to external carriers.

L. A. Savchenko [27] analyzed the condition of vehicles at state forestry "Liubomlskyi Forestry" located in Liubomlskyi district of Volyn region and suggested ways to increase the efficiency.

Many scientific works also deal with transport issues in other areas of Ukraine's economy. The article [29] considers one of the most urgent tasks in production, namely the problem of optimizing the movement of transport in the enterprise with the organization of warehouses logistics. To optimize operation, the article used mathematical methods and models in transport logistics and proposed a solution to the mathematical problem of linear programming. At the same time, the solution of this problem is carried out under the conditions of inflation in Ukraine and difficult current economic situation in general. Logistic efficiency

indicators were used to solve the transport problem. The search for methods of optimizing cargo transportation included the search for the effective location of warehouses and a closed transport task.

However, at this stage of the development of science, the problem of distribution of transportation of woodworking products by mode of transport has not been solved yet.

The purpose of this section is to analyze the existing preferences and future costs of transport deliveries of products of the woodworking industry and to draw up an optimal supply plan for the optimal use of different modes of transport.

The woodworking industry is a branch of the forest industry that performs mechanical and chemical-mechanical processing of wood and that uses various kinds of timber as raw materials for production.

The following groups of enterprises can be distinguished as part of the woodworking industry:

– enterprise carrying out primary wood processing (sawmill);

– secondary processing of wood (plywood, parquet, furniture, production of matches, chipboard, parts, standard houses, etc.);

– chemical-mechanical processing of wood (wood plastics, wood-fiber boards).

A special role is played by the production of fiberboard and chipboard, which provides an opportunity for the efficient use of sawmill and other woodworking production waste. This results in products that are in high demand and are the main source for the development of the furniture industry.

The woodworking industry is an important branch of the forestry sector. Its enterprises produce goods mainly for national consumers. However, a significant part of wood products is consumed in the national economy for further production and as tools. These products are used by the construction industry, agriculture, transport, etc.

Woodworking industry is regulated by many legal acts. The parliament of Ukraine is currently considering the draft law of Ukraine "On the wood market". It has to determine the legal, economic and organizational principles of the timber market, regulate timber purchase and sale relations, and is aimed at developing market relations in the woodworking industry to meet the needs of consumers on the principles of free and fair competition and sustainable use of forest resources [29].

Let us consider the example of the woodworking company "World of Wooden Products". The company was founded on July 5, 2001. Since then, it has been dealing with hardwood and softwood products, which include oak parquet, processed and unprocessed board. The company also offers wood drying services, loading services and installation works.

The company has a sales department "World of Wooden Products", which sells wooden and related products, namely varnishes, paints, filling cement, dyes, etc. Today the range of goods is about 200 items of various wooden products. The department also provides installation, polishing and varnishing services, dye selection and other construction services. It is possible to order goods and services online or in video chat, and delivery to the customer. The company's head office is located in Lviv [30].

The company's products are supplied to different parts of Ukraine and can be delivered abroad. To communicate with consumers, there is a special telephone line and the ability to communicate via e-mail. Among the transport modes chosen by consumers, the most common are rail and road transport. Having studied the operation of the enterprise in the previous years using original cargo documents, we found out that these two modes of transport are in equal demand. Thus, we can state that there are equal preferences for the use of these modes of transport [30]. In this case, the utility function looks like this:

$$U = m * p, \tag{2.21}$$

where m – distance (in km) covered by one vehicle with a capacity of 10 tons, transporting products of the woodworking industry, per month;

p – distance (in km) covered by one train freight car with a capacity of 10 tons, transporting products of the woodworking industry, per month.

Graphically, this function is represented by lines of indifference (Figure 2.14). That is, the provision of transportation by train and road transport are interchangeable. These quantities are taken on average.

The constraint function of the costs of the enterprise with two components of the cost of transportation is described as follows:

$$D = C_1 m + C_2 p, \tag{2.22}$$

where C_1 – the average cost of transporting products by one vehicle per 1 km,

C_2 – the average cost of transporting products by one train freight car per 1 km.

In (2.22) only m and p can change. Now, we determine p:

$$p = -\frac{C_1}{C_2} m + \frac{D}{C_2}, \tag{2.23}$$

Formula (2.23) is the equation of the line

$$y = -ax + b$$

where:

$$a = \frac{C_1}{C_2}, \quad b = \frac{D}{C_2}.$$

Suppose we have a map of indifference. On it, we draw a graph of the line (2.23) in the form FT (Figure 2.14). The angle of inclination of this line will depend on the coefficient

$$a = \frac{C_1}{C_2}$$

The distance of the line from the origin depends on the free term

$$b = \frac{D}{C_2}.$$

Line *FT* is a line of fixed costs of transport, each of its points reflects a set of consumption, in which the structural ratio of the components is different, and the sum of all total costs is the same and equal to the cost of *D*. The usefulness of transport options varies. The company will strive for such a use of transport services, in which the cost of transport is equal to *D* and which provide the best utility. This choice is represented by point *J* (Figure 2.14), which belongs both to the line of fixed costs and to the indifference curve. The analysis shows that the optimal ratios of components in the set of consumption are those in which the marginal utility of the components is proportional to the cost:

$$\frac{\partial U}{\partial C_i} = rP_{C_i}, \tag{2.24}$$

where r - coefficient of proportionality.

Now, let us maximize the utility function:

$$U(m, p) = m \times p \to \max. \tag{2.25}$$

Our problem can be considered as a problem of determining the conditional extremum using the Lagrange method. Then:

$$L(m, p, \lambda) = U(m, p) + \lambda(C_1 m + C_2 p - D) \tag{2.26}$$

Based on the algorithm of this method, we find the derivatives of *m, p* and λ and equate them to zero:

$$\frac{\partial L}{\partial m} = U_1' + \lambda C_1 = 0, \quad \frac{\partial L}{\partial p} = U_2' + \lambda C_2 = 0, \tag{2.27}$$

$$\frac{\partial L}{\partial \lambda} = C_1 m + C_2 p - D = 0 \tag{2.28}$$

where $U_1' = \frac{\partial U(m, p)}{\partial m}$ – marginal utility of road transport,

$U_2' = \frac{\partial U(m, p)}{\partial p}$ – marginal utility of rail transport.

Excluding λ from the system of equations, we obtain

$$\frac{U_1'}{U_2'} = \frac{C_1}{C_2}, \tag{2.29}$$

$$C_1 m + C_2 p = D, \tag{2.30}$$

Thus, we have a system of equations

$$\frac{p}{m} = \frac{C_1}{C_2}, \tag{2.31}$$

$$C_1 m + C_2 p = D, \tag{2.32}$$

The first condition states that the amount of transportation costs by both transport means must be the same, i.e.

$$C_1 m = C_2 p, \tag{2.33}$$

It means that

$$m = \frac{D}{2C_1}, \qquad p = \frac{D}{2C_2}, \tag{2.34}$$

Let us solve this problem for our specific example of the delivery of goods to consumers by different modes of transport.

The studied company uses the services of several trucking companies and railway. On average, it loads MAN, MERCEDES, and IVECO vehicles with a capacity of up to 10 tons. In general, on average, this company uses motor vehicles and train cars with a capacity of 10 tons. The volume of such vehicles is from 30 to 40 cubic meters. The average cost of transportation using road transport is UAH 16 per 1 km. The average speed is 45 km per hour.

A freight train travels much slower than a road vehicle, with an average speed of 36 km/h, but the cost of its use is much lower (UAH 0.8 per 1 km). Due to this fact, they are often used. The company mainly loads train cars with a capacity of 10 tons, given that the goods must be transported from the railway station to the location of the consumer company. Unloading and loading of products will cost additional UAH 200 per ton. In total for 10 tons of production, it makes 2000 UAH

regardless of distance. The Lviv woodworking company trades across all Ukraine. However, the average transportation distance makes 520 km. Thus, taking into account the distance, speed, cost of transportation, unloading and loading, and delivery of products by road from the railway station to the final destination, the average cost of transporting products by train makes 5.57 UAH per 1 km.

The total cost of transporting products per day is 3494.34 UAH. Then we present the constraint function as follows:

$$3494.34 = 16m + 5.57p, \tag{2.35}$$

Then

$$m = \frac{3494.34}{2 \times 16} = 109.2, \qquad p = \frac{3494.34}{2 \times 5.57} = 313.68 \tag{2.36}$$

Thus, it is most profitable for the company to make daily 313.68 km by train and 109.2 km by road vehicles. The results of solving this problem are presented graphically in Figure 2.14, where the most optimal line of indifference is the line to which point *J* belongs.

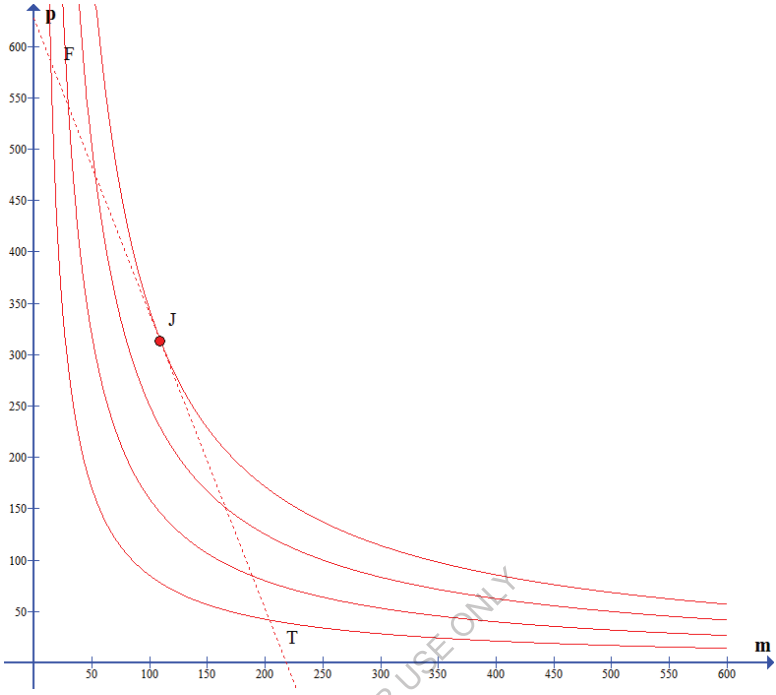

Fig. 2.14. The graph of expenses optimization for the transport enterprise

Thus, this section states an urgent need to use rail and road transport both in the transportation of raw materials and in the supply of intermediate and final products by companies in this sector. The research has determined that in order to achieve the successful distribution of different types of transport it is necessary to carry out transportation 313.68 km by train and 109.2 km by road vehicles per 10 tons of products.

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CONCLUSIONS

Ukraine continues to be a big industrial center of Europe. Together with certain fields that are traditionally classified as the industrial sector of the economy, services are becoming a leading factor in the social development. Scientific services are especially important among other services. The spread of modern information and computer technology forms the basis for closer communication between people located in different regions, although it can make less effective personal contacts among employees working in the same office. The availability of modern comfortable and fast transport also brings people together and activates business.

The monograph has defined that the scientific term "knowledge" is a fundamental theoretical category. Its essence as an economic phenomenon and basis for the future development of the society is studied by scientists of different branches: social scientists, philosophers, sociologists, lawyers and other representatives of the humanities. In addition, practical specialists, such as scientists in the field of information technology, innovators in various economic fields, managers, logisticians, and researchers of public administration problems explore these issues in other perspectives. The difficulty of defining this category is due to subjective and objective reasons. The category of "intellectualization" is closely related to this category.

This research combines theoretical approaches to assessing the role of science in the modern economy of the post-industrial transition. The research uses specific methods of analysis to study the condition and some current issues of transport services. The authors applied Lagrange multipliers method to optimize the transportation of wood products, studied road transportation in Ukraine using regression dependence, developed the information infrastructure of the transport company using graph theory, and determined the condition and prospects for the development of the transport industry in Ukraine based on trend analysis. The monograph has both theoretical and applied importance.