“Forecasting model and assessment of the innovative and scientific-technical policy of Ukraine in the sphere of innovative economy formation”

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Forecasting model and assessment of the innovative and scientific-technical policy of Ukraine in the sphere of innovative economy formation

Abstract

This research substantiates the expediency of introducing the instruments of neural network theory to the economic practice, since it appears to be a strong mathematical instrument and an alternative to the mathematical approaches currently known. The article suggests and presents a neural network model to forecast the innovative and scientific-technical development of the Ukrainian economy. The computerized modeling of the adapted neural network has been performed on the basis of Statistica Neural Networks (StatSoft Inc.) package. Taking into consideration the development of the leading countries of the world and Ukraine, this neural network model is based upon the indices reflecting basic results of the state social and economic, innovative, scientific and technical policy within the period of 2000-2013. The suggested technique allows determining the factors that have the greatest influence on the GDP of the country and predetermine its economic development. Among the considered factors, the greatest influence on the GDP growth is made by the amounts of Research and Development (R&D) financing. Not less important for the economic growth is the increase of investments in the basic capital. Among the factors, the least influence on GDP is made by the national budget expenditures on the innovative activity of enterprises. The received predictive data may provide the basis for working out a strategy of the innovative development of the country and regions, investment and innovative programs and budgets.

Keywords: neural network model, forecasting, scientific and technical, innovative policy, innovative economy.
JEL Classification: C45, C53, O38.

Introduction

At the present stage of the development of Ukrainian economy and at the time when the active transformation of all social life takes place, it is sensible to complete the urgent tasks of transition to the innovative economy. The prospects of the society development not only depend on the efficient use of available resources, but also on the ability of its members to produce and implement innovations. The state policy of the country to stimulate innovations must be based on the confirmation of the priority status of scientific technical and innovative development.

As early as the last century, the innovations were recognized as the main factor of economic development (Drucker, 1986; Santo, 1990; Knight, 1994) in case of interaction between economic agents and economic environment.

The scientists Bell (1973), Naisbitt (1982), Toffler (2000), Fukuyama (2008) unambiguously assert that, for many leading countries, the innovative economy created conditions for the formation of their global economic leadership. It is the main factor of the national economic stability, economic progress and fiscal sustainability.

The information received due to forecasting is required as a basis for planning and management of the activity of economic agents, as well as the reception of preliminary assessment of the results, the outcome of the approved decisions for the purpose of their optimization (Yurynets, 2014).

Therefore, certain steps were taken in Ukraine. However, there are too few of them to be able to confirm the direction of our country in the innovative ways of development. In the process of forming the innovation-driven growth model of the national economy, Honcharenko (2009) emphasizes the role and meaning of state institutes in the formation of innovative economy of the country, Bova (2010) focuses attention on the importance of forming the state management mechanism by means of national innovative system functioning, Panasiuk (2003) considers that, first of all, it is necessary to solve the issue of improvement of the approaches to forecast the scientific and technological and innovative spheres, and improvement of the process of managerial decision-making.

Forecasting is the important background for conducting the state regulatory policy of the country economy, in general, and its innovative sector, in particular, for coordinating the activity of all levels of the government related to the implementation of the social and economic and innovative development goals. The forecasting process remains an essential and strategic direction of further development. It becomes an integral part of the process of object operation at any level.

For planning of the development of the national economy, forming of the strategy of the social and

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economic development, and the strategy of national innovation, the system of various forecasts is used. This system includes social forecasts, economic forecasts, demographic forecasts, etc. (Melnyk, Vasina, Zheliuk, Popovych, 2011). The economic forecast defines and evaluates the main directions of the development of social and economic and state processes, reflecting a complex of the internal and external relations, the interdependence between the elements, first of all, at the macro level. The sources of information are the stored knowledge and experience, factual and statistical information, economic and mathematical models.

In order to forecast the innovative economy development, it is necessary to take into consideration the following principles: consistency of aim, appropriateness, alternativeness, systematicity, efficiency and scientific validation (Melnyk, Vasina, Zheliuk, Popovych, 2011). The unity of different models, methods, instruments for developing forecasts meet the above-indicated principles of economic forecasting, reflecting different sides of the process of forecast development.

The efficiency of management, planning and regulation of these processes, and taking decisions connected with the development of strategic goals, the assessment of opportunities and necessary resources for the achievement of the intended targets, the determination of the innovative strategy of the regions and branches, the selection of the alternatives and the preparation of the operational plans, projects, programs and budgets depend on the precision of the forecasting level of innovative processes of the economic development. That is why there arises a matter of choice of the best methodological approaches to the forecasting of the economic development of the country.

1. Literature review

The main reference points of the national policy in the scientific and technical and innovative spheres, as well as a comprehensive complex of measures which stimulate the scientific and technical and innovative activity, have been established in the conceptual bases and strategies of social and economic, scientific and technical and innovative development of Ukraine. The targets are rendering process, control and monitoring of scientific and innovation development indices, fulfilment of the forecasting investigations in order to determine scientific-technical, innovative development trends. The state government of Ukraine has also worked out the series of regulatory instruments concerning the forecasting of scientific-technical and innovative development activation, there were established the programs and measures for the implementation of the target goals.

The forecasts of social and economic, academic and technological and innovative development of Ukraine are mostly performed by the scientists of the Institute of Economics and Forecasting of the National Academy of Science of Ukraine and they serve as grounds for the approval of state managerial decisions. The research works of Halchynskyi (2003), Heiets (2003), Kinakh (2003), Semynozhenko (2003) substantiate the conceptual grounds of the state strategy of economic development of Ukraine. They are based on long-term and mid-term forecasting of the country development. The strategy is focused on the steady growth provision based on the innovative and investment modernization of the economy.

In the works of Aleksandrova (2007), Heiets (2007), Skrypnychenko (2007), Fedulova (2007) there was fulfilled the forecasting and there was analyzed the influence of the innovative factors over the economic development of Ukraine. Within the scope of the national programs, the specialists accomplished the forecasting and analytical investigations, offered the possible basic, optimistic and pessimistic development scenario, brought long-term and mid-term forecasts of scientific-technical and innovative development, formed a proposition for the direction of the national economy to the innovation-based development.

In economically and technologically developed countries of the world, it is actively introduced a state planning and forecasting in different forms, which is successfully adapted to the conditions of the market-based economy. Social process that is closely connected to academic and technological and innovative development is not performed spontaneously, but, in accordance with foresight methods, determination of directions is based on academic and technological forecasting methods (Georghiou, Cassingena, J., Keenan, Miles & Popper, 2008; Destatte, 2010; Könnölä, Salo, Cagnin, Carabias, Vilkkumaa, 2012). For the most part, the developed and offered neural network models of expert cooperation touch upon the question of the results of innovative activity forecasting for the certain industry players.

Over the last years, a considerable amount of researchers in the countries of Eastern Europe, including Ukraine, have already started using fuzzy logic and neurocomputing approaches. There has been projected a steady tendency for the increase of the role of forecasting in Russia. A brilliant group of scientists (Sokolov & Chulok, 2012; Ahamirzian, Blinkin, Gohberg, Kasimov, Kirpichnikov, Ogorodova, Filippov & Yaroslavtsev, 2014) are dealing with the determination of the most promising, for the country, areas of science, and technology that makes a significant contribution to the solution of social-economic problems and realization of the competitive

advantages of the country. They are detecting the grand challenges, threats, and opportunities connected with them, the promising innovative markets, radical products and technologies, fields of research in terms of seven promising directions.

Modern national forecasts of the innovative development of Ukraine do not coincide with the indices of the real situation with the economy. The analysis of the native research papers in theory and forecasting practice certifies the fact that not fully enough there are developed the forecasting models due to which there exists a possibility to detect the influence of factors of the innovative sector over the economic development of the country.

It is crucially important to develop the neural network model of macroeconomic framework, taking into account the indices that characterize innovative, scientific-technical policy of the country for the improvement of the national economy regulation, oriented to the innovation-based development and further design of forecasting and analytical programs of strategic innovative development of Ukraine.

2. Data and methodology

Neural network modeling refers to one of the powerful instruments when analyzing microeconomics, determining the directions of innovative, scientific-technical and socially economic policy of the country. Due to the neural networks, there are solved the problems of objects classification, forecasting and administration.

Neural network models of forecasting are deprived of certain limitations of the classical methods of forecasting (Hrabovetskyi, 2003; Aleksandrova, Skrypnychenko & Fedulova, 2007; Boychuk, 2014; Novakevych, 2014); monotony or periodicity of the future value, which is inherent to the numerous extrapolation methods; creation of complicated dependencies, because the neural networks are non-linear by their nature (contain a great amount of incoming information, between which there exist no evident regularities and interrelations); averaging of the predicted value, which is peculiar to the least squares method, average running or regression models; facilitate a solution of non-formalized or ill-formalized processes, are resistant to the constant changes of environment. Moreover, the forecasting made based on artificial neural networks does not allow any limitations regarding incoming information.

The task of this investigation is to build a neural network and receive the forecast of scientific-technical and innovative development of the Ukrainian economy, aiming to evaluate the influence of separate factors over GDP of Ukraine.

Due to the use of Statistica Neural Networks (StatSoft Inc.) package, which combines a user-friendly interface with a variety of choices of different kinds of neural networks, there was built a model of forecasting and evaluation of the state policy of scientific-technical and innovative development of the Ukrainian economy.

The neural network building process stipulates the following stages:

- Selection of the type of network for solving the formulated task.
- Studying of the neural network: determination of the quantitative meanings of the weight of each of the neurons based on retrospective or expert information.
- Check of neural network that passed the training phase, taking into consideration the data of the checking device.
- Application of network that has successfully passed the training and testing phases aiming to explain the formulated task.

For automatic generation of the neural network, there was used Statistics → Automated Neural Networks instrument. In the initial dialogue window, there is selected a variant of network creation for the regressive stimulation of the time series (Figure 1).

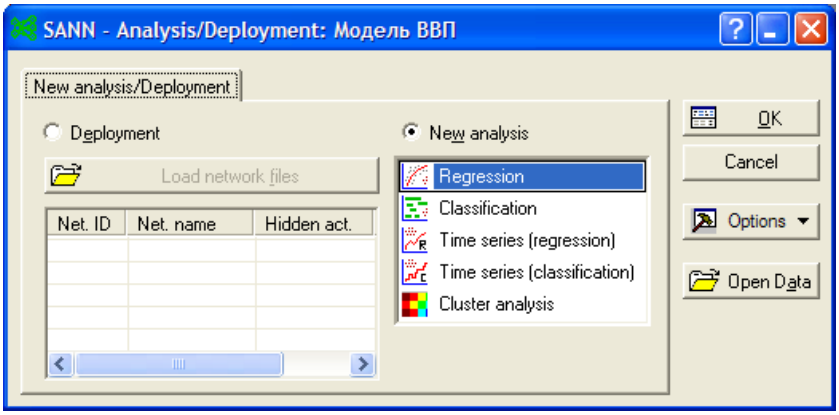

Fig. 1. The initial selection window of the mode of data analysis

Next, there takes place a selection of a set of dependent and independent variables, which are used for training (studying) the network (Figure 2). The incoming variables are: financing of the innovative activity from the state budget, financing of research and development (R&D), exploratory and constructive works from the state budget, investment in the basic capital. Outcome variable – GDP of Ukraine.

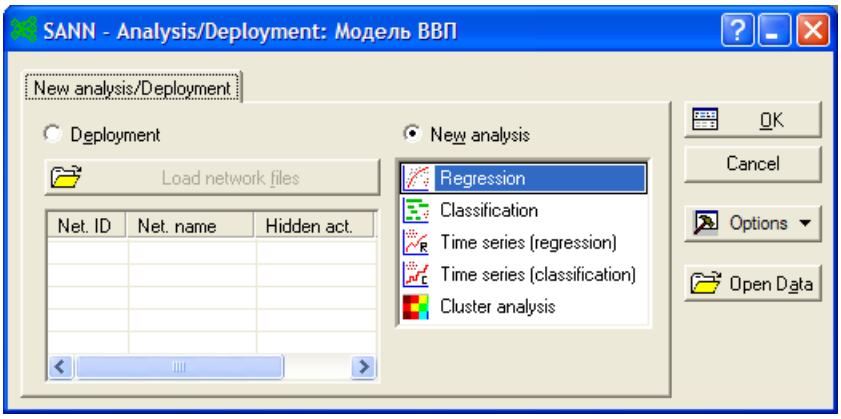

Fig. 2. Selection of data sets for the network training

In the following step, there is determined a minimum and maximum amount of neurons, variants of networks for training, networks for selection and assessment. After that, there is activated the process of training and networks selection.

The formulated problem was solved by means of radial basis function type (RBF) and multilayer perceptron (MLP) neural networks. The results of the training process and the network selection are shown in Figure 3. As a result of the performed experiment, there was received a multilayer neural network (multilayer perceptron MLP 5-8-1), which has the highest productiveness and the smallest training mistake.

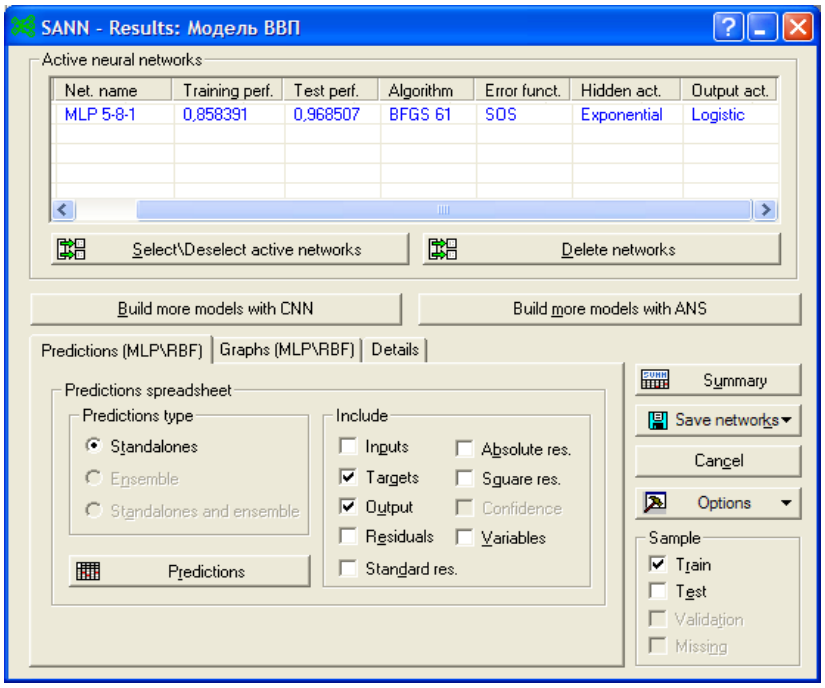

Fig. 3. The constructed neural network in STATISTICA package

So, the developed neural network model may be used as a resultant index forecasting instrument (GDP of Ukraine) in the methodological approach to the evaluation of scientific-technical and innovative development.

The input variables of neural model are the characteristics of scientific-technical and innovative policy of the country, the reference parameter – relevancy (quality of conformance) of the national policy to the national economy conditions oriented towards the innovation-based development (expert appraisement is within the following limits: 0 – low level of economic orientation towards the innovation-based development; 1 – high level).

Table 1 demonstrates the statistic data, which to the fullest extent characterize the state of scientific-technical and innovative activity in Ukraine.

Table 1. Key indicators to the model that evaluate the innovative and scientific-technical policy of Ukraine as the means of innovative economy formation (% of GDP)

Indicators	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Paid taxes and fiscal charges	29.1	27.9	30.5	29.8	26.3	30.4	31.6	30.5	31.4	31.6	29.0	30.6	31.6	29.4
Personal tax returns	3.73	4.34	4.82	5.10	3.81	3.92	4.23	4.82	4.80	4.91	4.72	4.63	4.84	4.80
Business profits tax funds	4.5	4.1	4.2	4.9	4.7	5.3	4.8	4.8	5.0	3.6	3.7	4.2	4.0	3.7
VAT and excise duty receipts	6.91	6.42	7.78	6.70	6.79	9.48	10.81	9.72	11.1	11.6	11.7	13.3	13.1	12.1
Financing of research and development (R&D) from state budget	0.36	0.37	0.32	0.40	0.42	0.39	0.37	0.39	0.41	0.37	0.35	0.29	0.32	0.29
Financing of innovative activity from state budget	0.005	0.027	0.020	0.035	0.018	0.006	0.021	0.020	0.036	0.014	0.008	0.011	0.015	0.002
Summary budget non-tax receipts	7.39	6.91	7.22	6.19	5.90	5.91	5.90	5.33	4.82	7.01	5.71	4.62	5.71	5.62
Local budget tax receipts	6.89	7.21	7.33	5.70	5.21	5.22	5.61	6.13	6.20	6.41	6.22	5.61	6.10	6.10
Summary budget expenditures	28.28	27.19	26.71	28.42	29.29	32.12	32.19	31.41	32.60	33.61	34.92	32.00	34.89	33.61
Local budget expenses for the countrywide functions	3.89	3.81	3.82	3.71	3.63	3.52	3.70	3.41	3.19	3.71	4.10	3.82	3.90	4.10
State budget expenses for education	2.31	2.32	2.11	2.20	2.11	2.21	2.23	2.10	2.31	2.60	2.70	2.11	2.10	2.10
Investments in the basic capital	13.89	15.94	16.51	19.09	21.92	21.11	23.01	26.19	24.52	16.60	13.93	15.52	15.41	14.32
Public investments	1.29	1.51	1.42	2.13	3.30	1.89	2.20	2.52	2.31	1.23	1.42	1.41	1.32	1.31
Money supply, M1	12.2	14.6	17.8	19.3	19.4	22.3	22.7	25.2	23.7	25.6	26.5	24.0	26.1	29.9

Source: [26; 27].

In the investigation, there were used the data regarding the social-economic, scientific-technical and innovative activity of 13 advanced countries like Austria, Great Britain, Germany, the Netherlands, the USA, Finland, France, Switzerland, Sweden and others. The indices were received thanks to the demonstrated research findings, statistical materials, represented by different, especially international organizations: the International Monetary Fund, the Organization for Economic Cooperation and Development (OECD), State Statistics Committee of Ukraine.

3. Results of investigation

To explain and form the way, extent, scale of changes and nature of the government regulation of the economy with the purpose to achieve goals of scientific-technical and innovative development, there was carried out the analysis of the peculiarities, signs of impact of each factor of the suggested model on the result, at the same time, changing, in turn, each of the incoming data (value) of the model and allowing the neural network to evaluate the government activity. This model logically and correctly interprets the content of incoming data and is able to specify a scope of occasional changes in scientific and technical, innovative, and socially economic policy of the country.

Analyzing the amount of financing of the innovative activity from the national budget in Ukraine within the period of 2000-2013, it should be noticed that there is observed an undulant tendency towards the decrease of the specific weight of this index in GDP (Table 1). However, the establishment of the economic procedure oriented towards the innovation-based development in our country will become possible in case of the increase of the amount of the innovative activity financing. From Figure 4, we see that that the increase of the innovative activity financing from the national budget leads to GDP growth. In case of innovative activity financing increase by 0.001%, GDP will grow on an average by 0.0033%.

The received data provide evidence of the availability of direct dependence between the financing of the innovative activity and neural network evaluation concerning the degree of contribution made by the national policy to the formation of the innovative economy, demand for the national innovations development, scientific and technical programs.

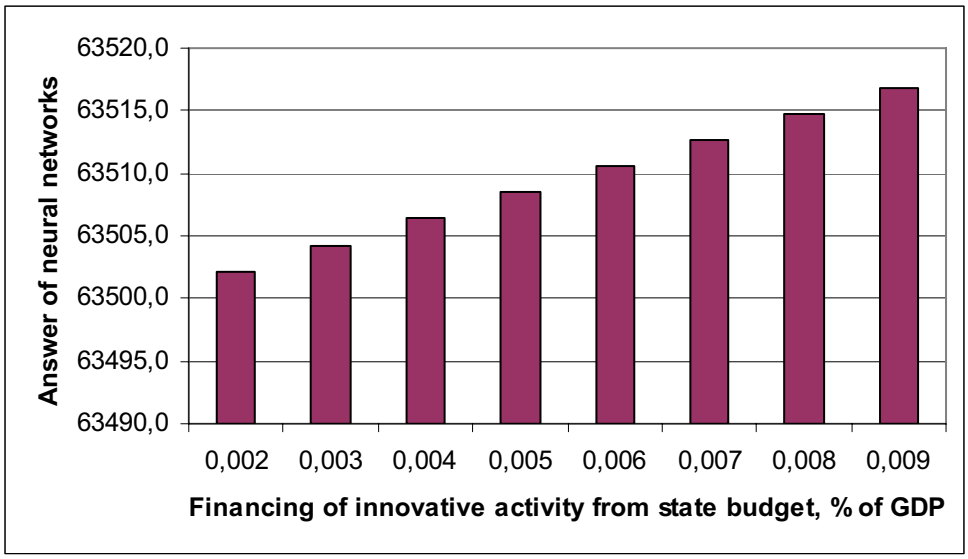

Fig. 4. The influence of the innovative activity financing from the national budget over GDP of the country

Analyzing the amount of research and development financing in Ukraine during 2000-2013, it should be noticed that there is observed a tendency towards the decrease of the specific weight in GDP (Table 1). It may be seen from Figure 5 that the increase of the research and development financing from the national budget leads to the GDP growth. Subject to the increase of the research and development financing by 0.01%, GDP will grow on the average by 0.77%.

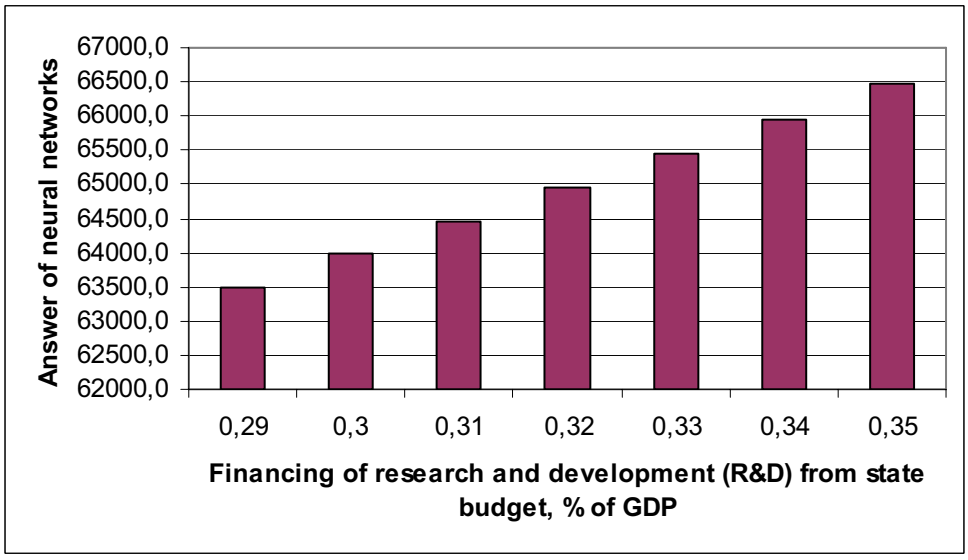

Fig. 5. The influence of the research and development financing from the national budget over GDP

The economic function of every country is provided by the expenses for science and economic activity. Today, science expenditures have significantly decreased. Besides the increase of the research and development financing from the national budget, there is required a support and a corresponding extension of the alternative sources of financing: deductions from special funds, commercial scientific activity, introduction and maintenance of the innovative management tools, for example, the innovation vouchers, etc.

Carrying out the investigation of the amount of investments in the basic capital in our country, it is easy to notice that starting from 2008 there is observed a steady tendency towards the decrease of their specific weight in GDP (Table 1). Nevertheless, we consider that the extent of national real investments (in basic capital) should increase. From Figure 6, it may be seen that the increase of investments in the basic capital leads to GDP growth. Subject to increase of investments in the basic capital by 0,1%, GDP will grow on the average by 0,7%.

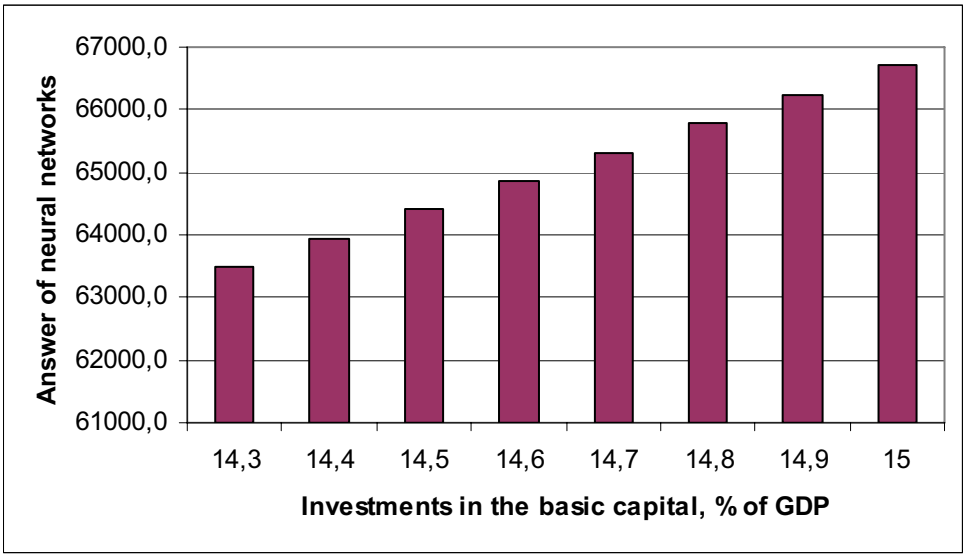

Fig. 6. The influence of investments in the basic capital over GDP

The construction of market economy in Ukraine oriented towards the innovation-based development should provide the excess of expenses from the national budget for recreation, substantial renovation of extremely old-fashioned basic capital based on the innovative footing (renovation, modernization, replacement by more intense) improvement of the investment policy. At the same time, the government should create the conditions for the development of different sources of the basic capital of enterprises renovation financing. An important aspect under the condition of absence of the required amount of financial resources for the investment in the basic capital is the question of improvement of the effectiveness of their use.

We think that it seems logical the opinion of economists and scholars (Halchynskyi, 2005) who consider that, for the effective use of the basic capital, there is required the intensification of the role of the state as the institutional factor on the capital market, as well as the intellectualization of productive facilities. Heiets (2002) claims that, for the maintenance of the adequate fund equipment of the domestic enterprises, there should be annually invested from 20 billion dollars. The government should join to the provision of enterprises with the necessary equipment, funds in order to broaden the government investment programs of priority-oriented economic sectors, to reform old-fashioned economic structure, to improve the competitiveness of the domestic production and state, in general.

Conclusions

In the modern context of unstable economic development in Ukraine, the special attention should be paid to the extension of the forecasting sphere. There should be clearly shaped the goals, aims and tasks with the determined directions of their achievement. There should be also paid much attention to the quality of forecasting, definition of macroeconomic development forecasts, as far as it affects the effectiveness of management and managerial decision-making on the macro-level and, to a great extent, the mechanism of their implementation on meso-level and micro-level. Neural network model of the scientific-technical and innovative forecasting of economic development in Ukraine has been realized due to the use of Statistica Neural Networks (StatSoft Inc.) package. This model is based on indices that reflect the primary results of the national innovative, scientific and technical policy of the advanced countries of the world and Ukraine and is aimed at switching the national economy to the innovation-based development and optimization of economic regulatory processes.

The proposed methods give an opportunity to discover factors that characterize scientific-technical and innovative activity, and, which have the greatest influence over GDP of the country and determine economic development of the country. The analysis of the received forecasting results testified that, among the analyzed factors, the greatest influence over the GDP growth has the amount of the research and development financing. Equally important for the economic growth is the increase of investments in basic capital. The least influence over GDP, among other factors, have the expenses of the national budget for the innovative activity of enterprises. The administrative apparatus of our country should take into consideration the experience of the advanced countries of the world, which, at the time of crisis (economic, financial, political), focused their attention to the development of innovations, system constructing enterprises and increased their expenses for scientific investigations

and technological developments, aiming to increase the competitiveness and economic growth of the country. The development and implementation of innovations will give the opportunity to increase dramatically a labor productivity, economic operating performance ratio.

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