Modeling the Impact of Social and Economic Factors on Innovative Development of Healthcare in the Conditions of Sustainable Development of Ukraine

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Abstract—The aim of the article is to determine the impact of social and economic factors on innovative development of healthcare using modeling with a neural network. The article grounded the necessity of neural net concept tools introduction into the health sector practice in the conditions of sustainable development of Ukraine. The proposed model is based on social and economic development indicators of Ukraine and the advanced countries in the world. Indicators characterizing the results of the Ukraine's social, economic, innovation policy for 2000-2016 have been used in the model. Calculations have been made by applying functional modules and standard procedures implemented in software package Statistica Neural Network. Statistical data on economic and social, innovation activity of advanced countries, such as Austria, Great Britain, Denmark, Netherlands, Norway, Finland, Sweden, Belgium and USA have been used. Empirical base for the analysis of foreign countries activities includes data for 1980-2016. All data used in our analysis are taken from State Statistics Committee of Ukraine, IMF and OECD. The methodology has made it possible to determine the factors that affect the GDP of Ukraine. Public healthcare financing has the greatest influence over the GDP growth. No the least important for the country's socio and economic growth is the increase of expenditures of the state budget on the research and development. Forecast of public healthcare financing and public research and development financing for 5 years has been carried out. The proposed model for assessing the impact of social and economic factors on innovative development of healthcare allows to predict the level of public healthcare financing, research and development financing from the state budget. This will help to develop effective measures and implement a healthcare innovation policy in the conditions of sustainable development of Ukraine. The received forecast data may provide the basis for the healthcare innovative development strategy design, programs and budgets, healthcare innovation projects.

Keywords—modeling, neural network, factors, healthcare, indicators, healthcare innovation policy, budgets

I. INTRODUCTION

The health sector is vital to determining the economic performance and stability of a country and a key sector in the implementation of local and national goals for sustainable development. The health sector: has a positive impact on the economic performance of other sectors in the national economy, through the jobs it generates and from the purchase of goods and services; has a major role to play in reducing social exclusion at the local level, due to its impact on employment, working conditions and household income; can increase its status as a key sector for driving forward the implementation of local and national goals for sustainable development, by enhancing its employment, training and purchasing functions both locally and nationally. Health systems play an increasingly important role in driving inclusive and sustainable development through responsible practices in the areas of employment and the purchasing of goods and services. This social benefit of health systems is not well documented or currently considered in many mainstream policies and practices [1].

Health systems in Europe are facing the combined challenge of increasing demand because of a rising burden of chronic disease and limited resources. This creates a pressing need for a fundamental rethink of the way health services and systems are organized and financed. Experiences in European countries show that it is possible to improve services through innovation locally, but more needs to be done to ensure that they benefit the population at large [2].

Development of the healthcare sector as key element of a competitiveness and state social policy is a top priority in Ukraine. The healthcare should ensure satisfaction of immediate "clients" needs. Citizens needs access to affordable and high-quality health services. It is a very important task for Ukraine in the conditions of sustainable

development of the economy. The main sustainable development goals of Ukraine are to ensure healthy lifes, sustainable economic growth, innovations. The development of Ukraine's healthcare system and economic agents depends on the need to increase the level of quality of healthcare services. The level of financing for research and development, innovation and health spending in different countries describe the impact of healthcare services quality. The demand for innovations in the healthcare sector in Ukraine is still quite low.

Current social-economic situation in healthcare system shows the high level of application of outdated technologies, a low level of transfer of modern medical technologies and the development of national medical innovations in healthcare. Extremely low innovation activity is related to imperfection of innovations management and economic mechanism of financing innovations [4].

Statistics show a rapid deterioration in the health status of population. The socio-economic crisis in Ukraine has indicated the decreasing level of health and research and development financing [5]. All these problems significantly inhibit the healthcare innovation development.

The Ukraine's healthcare system needs the transformations, the introduction of innovations and an effective model of healthcare funding. Implementation of the modern health care reform strategy can be achieved through the efforts of state and scientific institutions. It provides for the introduction of a results of new scientific research. It is necessary to carry out a forecasting of the factors affecting on the innovative development of the health care sector in Ukraine.

II. METHODOLOGY OF RESEARCH

A. Research Objectives

Neural networks are a modern tool for economical and mathematical modeling of the development of healthcare systems and socioeconomic forecasting. Neural networks to predict the effects of important social and economic factors on the innovative development of the healthcare sector in Ukraine and socially-oriented and innovation-oriented European countries have been used.

The research objective is to build a neural network model for evaluating the public health financing and public research and development financing as indicators and to perform analysis the forecasting results. The execution of the task will allow to evaluate the impact of social and economic factors on the innovative development of healthcare and GDP of Ukraine. The next task is to forecast public health financing and research and development financing from the state budget.

B. Neural network learning process

Neural network learning and calculations have been made by applying functional modules and standard procedures implemented in software package Statistica Neural Network. The generalized regression neural network has been built.

The generalized regression neural network is a very useful tool to perform predictions and comparisons of system performance in practice and is one of the most popular neural networks. The generalized regression neural networks applications are able to produce continuous valued outputs. Training and testing of generalized regression neural network were carried out by means of tool, which is capable of solving the neutron problem with high performance and generalization capability [6].

Neural networks are organized in layers of neurons. For this reason, connectionist models are organized in layers of units. Any number of units may exist within each layer, and each unit of each layer is typically linked with a weighted connection to each node of the next layer. Data are supplied to the network through the input layer. The neural network architecture defines its structure including the number of hidden layers, number of hidden nodes, and number of nodes at the input and output layers [6].

In our article in generalized regression neural network, units are organized into four layers: an input layer, the first hidden layer (first intermediate Radial Basis layer), the second hidden layer (second intermediate Linear layer), and an output layer.

The nodes of the hidden layer process input data they receive as the sum of the weighted outputs of the input layer. Nodes of the output layer process input data they receive as the sum of the weighted output of the units within the hidden layers, and supply the system output [7].

Network learning is a very important process. The training of generalized regression neural network is very fast because the data only needs to propagate forward once, unlike most other neural networks, where data may be propagated forward and backward many times until an acceptable error is found. The performance of the network is evaluated based on the comparison between the computed (predicted) output and actual (desired) output value. The generalized regression neural network use equations that are connected using weighting factors. The multilayer perceptron (MLP) is the most common and successful neural network architecture with generalized regression neural network topologies [8].

The measurements of prediction accuracy of the constructed neural model are carried out using the coefficient of determination that reflect the adequacy of the constructed model. The generalized regression neural network learning process includes the following: pre-processing, training, testing, validation, analyzing graph data, and storage the results. Automated Neural Networks have been used to automatically generate the regression neural network.

The developed neural model carries out an independent expert evaluation from 0 to 1. Expert assessment has limitations: 1 - the highest degree of the orientations of a state policy towards innovative development of the health sector; 0 - the lowest degree of the orientations of a state policy towards innovative development of the health sector.

As a result of training and selection of networks, a Radial Basic Function (RBF) and a Multilayer Perceptron (MLP) type neural network have been created. The constructed neural network for the public health financing is represented in Fig. 1.

As a result of neural modeling the Multilayer Perceptron (MLP 12-14-1) for the public health financing which has the

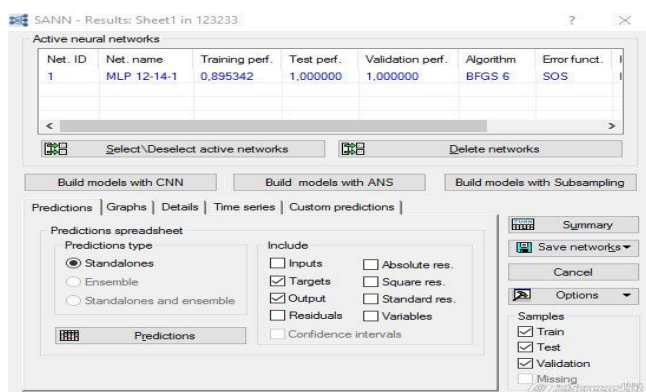highest productivity and the smallest error of training has been obtained.

Fig. 1. Neural network for the public health financing.
Source: formed by the authors.

The constructed neural network for public research and development financing is represented in Fig. 2.
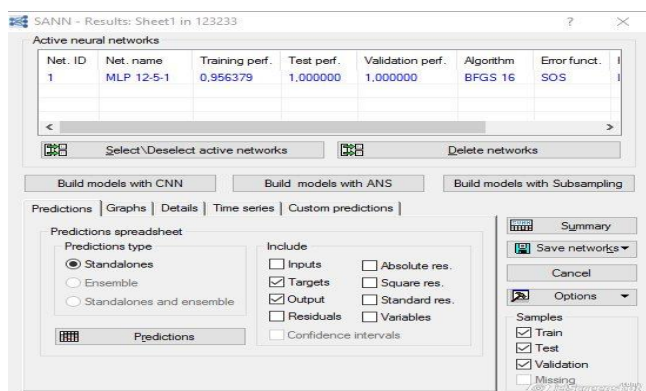

Fig. 2. Neural network for the public research and development financing.
Source: formed by the authors.

As a result of neural modeling the Multilayer Perceptron (MLP 12-5-1) for the public research and development financing which has the highest productivity and the smallest error of training has been obtained.

C. Data sources and input variables for constructing a neural model

The main indicators of social and economic development characterizing the revenues to the state budget and expenditures from the state budget have been applied. All data used in our analysis are taken from State Statistics Committee of Ukraine, IMF and OECD. The input data for neural network is represented.

Input data for neural network: business profits tax funds, (% of GDP); personal tax returns, (% of GDP); summary budget non-tax receipts, (% of GDP); VAT and excise duty receipts, (% of GDP); paid fiscal charges, taxes, (% of GDP); GDP, $; public healthcare financing, (% of GDP); public healthcare financing, (% of GDP); public research and development financing, (% of GDP); capital investments, (% of GDP); state budget expenses for the innovative activity, (% of GDP); money supply, (% of GDP); summary budget expenditures, (% of GDP); local budget tax receipts, (% of GDP); local budget expenses for the countrywide functions, (% of GDP); budget expenses for education, (% of GDP) [9].

TABLE I. INPUT DATA FOR NEURAL NETWORK

The main indicators	Year					
	2000	2004	2006	2010	2014	2016
Business profits tax funds, (% of GDP)	4.51	4.70	4.80	3.71	2.60	4.13
Personal tax returns, (% of GDP)	3.73	3.81	4.23	4.72	4.80	4.132
Summary budget non-tax receipts, (% of GDP)	7.39	5.91	5.90	5.71	5.10	6.92
VAT and excise duty receipts, (% of GDP)	6.91	6.79	10.80	11.71	14.00	12.56
Paid fiscal charges, taxes, (% of GDP)	29.1	26.3	31.6	29.0	23.5	27.10
GDP, $	21272314 3200	29969262 4000	33025258 0600	32363137 2500	31862580 0000	37942540 8544
Public healthcare financing, (% of GDP)	5.59	6.61	6.39	7.81	7.10	5.80
Public research and development financing, (% of GDP)	0.36	0.42	0.37	0.35	0.29	0.3
Capital investments, (% of GDP)	13.89	21.92	23.02	13.93	13.10	14.57
State budget expenses for the innovative activity, (% of GDP)	0.005	0.018	0.021	0.008	0.019	0.028
Money supply, (% of GDP)	12.3	19.5	22.7	26.5	34.8	36.3
Summary budget expenditures, (% of GDP)	28.28	29.29	32.19	34.93	33.40	31.20
Local budget tax receipts, (% of GDP)	6.89	5.21	5.61	6.23	5.60	7.45
Local budget expenses for the countrywide functions, (% of GDP)	3.89	3.63	3.71	4.10	3.70	3.81
Budget expenses for education, (% of GDP)	2.31	2.11	2.24	2.70	1.80	2.33

Source: formed by the authors according to sources [9; 10; 11].

Statistical data on economic and social, innovation activity of advanced countries, such as Austria, Great Britain, Denmark, Netherlands, Norway, Finland, Sweden, Belgium and USA have been used. Empirical base for the analysis of foreign countries activities includes data for 1980-2016.

III. RESEARCH RESULTS

In accordance with the developed neural model forecast of public health financing and public research and development financing for 5 years has been carried out.

A. Forecast of public health financing

Based on calculations the increasing in the public health financing will lead to an increase in GDP of country (the resulting GDP share of public health expenditures) has been established. The economic measures oriented towards the sustainable development of Ukraine will only become possible, when the amount of the public health financing is to increase. In a case of public health financing grow by 0.01% GDP will increase on an average by 0.02%.

The resulting data provide evidence of the availability of direct dependence between public health financing and neural network evaluation concerning the level of contribution made by the state policy to the creation of the national economy with innovative development of the health sector. From Figure 3 we observe the forecast of public health financing in Ukraine (% of GDP). It demonstrates the decline and growth of public expenditures on health.
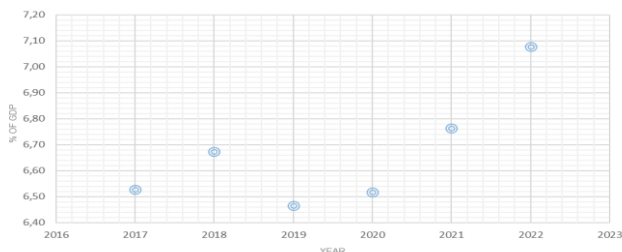

Fig. 3. Forecast of public health financing (% of GDP).
Source: formed by the authors

Of primary concern in Ukraine should be the sustainability high level of public funding for the health sector. It is important to create in Ukraine demand for ensure the provision of health-care goods, services and information for improving the quality of life of the population. The government should consider providing resources for innovative changes in the medical sector in Ukraine.

B. Forecast public research and development financing

Carrying out the analysis of the amount of public research and development financing in Ukraine, it is easy to understand the sequence of problems in reducing the expenses for new research, innovations. We consider that the extent of public research and development financing should grow.

Finally, the increasing in the public research and development financing will lead to an increase in GDP of country. Subject to grow of public research and development financing by 0.001%, GDP will increase on the average by 0.6%.

From Figure 4 we observe the forecast of public research and development financing. It demonstrates the decline and growth of public expenditures on research and development.
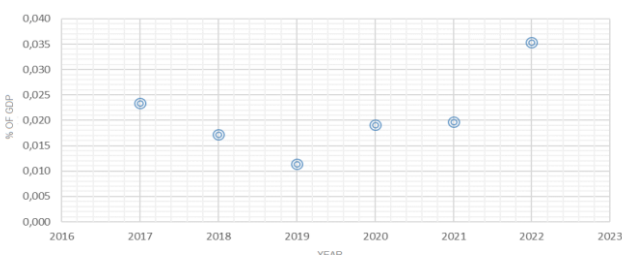

Fig. 4. Forecast of public research and development financing (% of GDP).
Source: formed by the authors

The public research and development financing is not sufficient in comparison with developed countries. Effective research and development programmes improve the performance scientific activity, initiation of the innovative management tools. It is important to create in Ukraine a demand for new developments and research in the field of healthcare, medical technologies, medical products, procedures, modern diagnosis, treatment, rehabilitation and prevention techniques.

IV. CONCLUSIONS

Thus the proposed methodology for identification of social and economic factors defined that not only understatement of governmental financial support. Public health financing has the greatest influence over the GDP growth. No the least important for the country's socio and economic growth is the increase of expenditures of the state budget on the research and development. The proposed model for assessing the impact of social and economic factors on innovative development of healthcare allows to predict the level of public health financing, research and development financing from the state budget. Research and development in healthcare is possible through an effective policy of the state. it is important to use the information obtained through neural network model. The proposed neural network model for assessing Ukrainian innovation policy in the health care allows us to predict the need for public research and development funding and public health financing. This will help to develop effective measures and implement a healthcare innovation policy in the conditions of sustainable development of Ukraine. The received forecast data may provide the basis for the healthcare innovative development strategy design, programs and budgets, healthcare innovation projects.

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