DIGITAL SERVICE FOR SCENARIO FORECASTING OF SOCIO-ECONOMIC INDICATORS OF ENTREPRENEURIAL ACTIVITY OF RUSSIA

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ABSTRACT

Aim of the study: *In the world and in Russia, the development of a digital state and a digital economy is relevant. Within the digital state, it is important to create a service for predicting socio-economic indicators based on modern methods and models of econometrics and machine learning, and make it accessible and convenient to use. The aim of this research is to develop requirements for a digital scenario forecasting service, to study possibilities of its realization on the basis of information-analytical system "SHM Horizon", developed by the authors at the Plekhanov Russian University of Economics.*

Methodology: *This study analyzes the needs for scenario forecasting of socio-economic indicators at the federal, regional, municipal and corporate levels. The main functional and non-functional requirements for such a service and its software architecture are developed. The analysis of the information-analytical system "SHM Horizon" is carried out, approaches to its development are proposed to improve its models and methods using a system of multiple linear regression equations, a multilayer perceptron, regression decision trees and a neuro-fuzzy inference system ANFIS and the implementation on this basis of the scenario service forecasting social and economic indicators of the Russian Federation.*

Conclusion: *The theoretical significance of the obtained results lies in the development of the theory of constructing hybrid systems for scenario forecasting of interrelated time series with structural shifts, which include time series of socio-economic indicators. The practical significance lies in the development of requirements for the scenario forecasting service and its architecture.*

Keywords: Digital State, Digital Service, Scenario Forecasting, Socio-Economic Indicators Of The Russian Federation, Time Series, Hybrid Information And Analytical System, Neural Networks, Decision Trees, Multiple Linear Regression, ANFIS (Adaptive Neuro-Fuzzy Inference System), Microservice Architecture.

INTRODUCTION

In recent years interest in the digital state has increased, both in the scientific community and among practitioners implementing projects for the digital transformation of the state and its various institutions. An important function of digital state is forecasting socio-economic indicators, such as macroeconomic indicators, indicators of the social and financial sphere,

investments, science and innovation, etc. These forecasts are needed both by the authorities at the federal, regional and municipal levels, and business.

Within the framework of the digital state, it is necessary to create a service for predicting socio-economic indicators based on modern methods and models, to make it convenient and accessible for all interested user groups. This service is an important component in the development and implementation of strategies for the socio-economic development of the country and its regions, municipalities, entire sectors of the economy, as well as large companies and corporations.

The purpose of this article is to develop requirements for the scenario forecasting service for socio-economic indicators of the Russian Federation, the composition of its components, as well as study the necessary modifications of the information and analytical system "*SHM Horizon*" (Kitova, 2019; Kitova, 2016) to turn it into a modern service that meets the specified requirements.

The development of the digital state and the digital economy in Russia is based on the achievements of Soviet science and technology, the experience of implementing enterprise automated management systems in our country, sectoral and republican automated management systems (OASU and RASU), as well as the project of the National automated system for collecting and processing information for accounting, planning and management (OGAS). The author of the OGAS project, the theorist of the information society and the digital state was Academician V.M. Glushkov. In the works of leading Soviet scientists V.M. Glushkov (Glushkov, 1975; Glushkov, 1980; Glushkov, 1982): A.I. Kitov (Kitov, 1961), as well as in the works of a number of Soviet, Russian and foreign scientists, various aspects of building a digital state and the use of economic and mathematical methods for managing the country's economy, including for its planning and forecasting, are considered. It is important to note that it was the USSR that was the leader in the development of the theory and practice of the digital state and the digital economy.

To manage the economy, the ability to predict socio-economic indicators is needed. An important place here is occupied by econometric models, the elements of which are regression equations. Econometric models, as a direction of forecasting, were proposed by the Nobel laureate RL Klein (Klein, 1955). The first regression models for forecasting the development of the country's economy appeared in the United States in the 1950s, then this experience was successfully used in other countries, including Russia. The works of T. Naylor (Naylor, 1975), A.P. Ermilov (Ermilov, 1987); Yu. A. Chizhov (Chizhov, 1977) are devoted to the description of various econometric models used to forecast the economy. In the book "World Economy" J. Forrester (Forrester, 2003) proposed a practical application of system dynamics in the study of complex socio-economic systems.

In the USSR, when developing plans, regression models were successfully used to predict consumer demand of the population. It should be noted the well-known books of T. Anderson, J. Johnson (Johnson, 1980), M.J. Kendall, A. Stewart, E. Kane and others. In Russia, econometric methods and regression models were studied and applied in the works of E.M. Chetyrkin, I.L. Kalikhman, S.A. Ayvazyan, V.S. Mkhitaryan, N.P. Tikhomirov, V.I. Motorina, I.I. Eliseeva. An overview of econometric models of Western economics is given in the work of I.B. Kolmakov. The work is devoted to the description of the econometric country model of Russia.

With the development of data mining and machine learning, these models and methods began to be applied to forecasting time series. The peculiarities of the time series of socio-

economic indicators are relatively short data series, the presence of structural breaks and the relationship between different groups of indicators. These features require the construction of an ensemble of hybrid models that combine traditional regression models and methods with models of neural networks, decision trees, and neuro-fuzzy models.

Neural networks have proven to be an effective method for forecasting time series. Various aspects of the use of neural networks for forecasting are considered. A number of works deal with the issues of forecasting economic data using neural networks. Methods of solving applied problems of forecasting time series using recurrent neural networks are considered. Decision trees are also an effective method for forecasting time series. The use of a hybrid approach for forecasting time series is considered in many works by leading Russian and foreign scientists.

The authors are developing a specialized information and analytical system "SHM Horizon", which allows scenario medium and short-term forecasting of more than 300 socio-economic indicators of the Russian Federation based on an ensemble of hybrid models combining models and methods of multiple linear regression with models of neural networks (multilayer perceptrons), regression decision trees, as well as neuro-fuzzy ANFIS models. Its architecture, implemented models and methods are described in detail in (Kitova, 2019; Kitova, 2016). At the moment, the SHM Horizon system exists in the form of separate modules, and to perform the functions of a scenario forecasting service for socio-economic indicators on the digital state platform, its completion is required. In Russia, there are other systems for forecasting socio-economic indicators, but they are closed proprietary systems and are aimed at solving individual specific problems.

As a result of the analysis, it was revealed that at the moment, within the framework of projects for building a digital state and a digital economy in the Russian Federation, there is no public service for scenario forecasting of the socio-economic indicators of the Russian Federation, and its creation is important.

METHODOLOGY

The theoretical basis of the work is a dialectical approach to the study of patterns of formation and development of the digital economy and the digital state, econometrics, models and methods of data mining and machine learning, the work of Russian and foreign scientists and specialists in the field under study, as well as in the field of theory and practice of economic management, economic and mathematical methods, computer science and information systems, software engineering.

The methodological basis of the research is a system-structural approach to the analysis of the problems under consideration. Economic and mathematical methods, methods of software engineering, methods of econometrics and machine learning were used to solve applied problems.

The information base of the study consists of regulatory documents of the Russian Federation, the national project "Digital economy of the Russian Federation", Federal program "Information society", the "Strategy of information society development in the Russian Federation for the years 2017-2030", materials of RosStat of the Russian Federation, research of the World Bank, international consulting and analytical companies, results of research institutes, funds and organizations of Russia and international organizations, materials of periodicals and the Internet.

Data sources for calculating indicators include data from the Unified interdepartmental information and statistical system (EMISS), including data from RosStat, the Bank of Russia, data from Russian regions, and others.

The basic model of the system reflects the inertial development of indicators while maintaining the existing trends in factor dependencies and the absence of serious financial and political “disturbances”. The perturbed trajectories are determined by the influences of the Government of the Russian Federation, the conjuncture of world markets and other factors reflecting the features of the problem under study. Therefore, it is the scenario indicators set by the experts that determine the type of the forecast trajectory. Scenario indicators include: average export prices for oil, international gold and foreign exchange reserves, money supply, refinancing rate of the Central Bank. The calculations are based on the use of the system of national accounts, the principles of econometric modeling, the system of expert assessments. Models for calculating forecast indicators are presented in the form of systems of regression equations, based on the results of computer experiments, statistically significant parameters are selected for each equation, the influence of which corresponds to the logic of economic processes. If the quality and accuracy of forecasting is unsatisfactory for a number of indicators, then an ensemble of hybrid models (neural networks, decision trees, neuro-fuzzy ANFIS model) is used to predict them.

RESULTS AND DISCUSSION

The digital service for scenario forecasting of socio-economic indicators of Russia will be in demand by government agencies and social organizations. This service will help you build sound development strategies at the federal, regional, municipal and industry levels, track their implementation and help to identify and prevent negative trends in advance. This service will be in demand by businesses, primarily large companies and corporations whose strategies and operations depend on the country's socio-economic development indicators.

The following are the main requirements developed by the authors for the digital service for scenario forecasting of socio-economic indicators, which is being developed at the Department of Informatics of Plekhanov Russian University of Economics on the basis of the information and analytical system "SHM Horizon".

When creating a digital scenario forecasting service, the authors suggest using the following conceptual scheme of the system of scenario forecasting models for indicators of socio-economic development of the Russian Federation (Figures 1 and 2). It is proposed to use models for calculating forecast indicators presented in the form of systems of regression equations in SHM Horizon system.

A digital scenario forecasting service should be able to verify models, i.e. assess the quality and accuracy of forecasts. To do this, you can use the forecast quality assessment module in SHM Horizon: the quality of equations is determined by calculating the coefficients of determination (R2), Darbin-Watson (DW) criterion, and Fisher statistics (F). The accuracy is estimated by constructing a retro forecast and calculating the average relative error (MAPE).

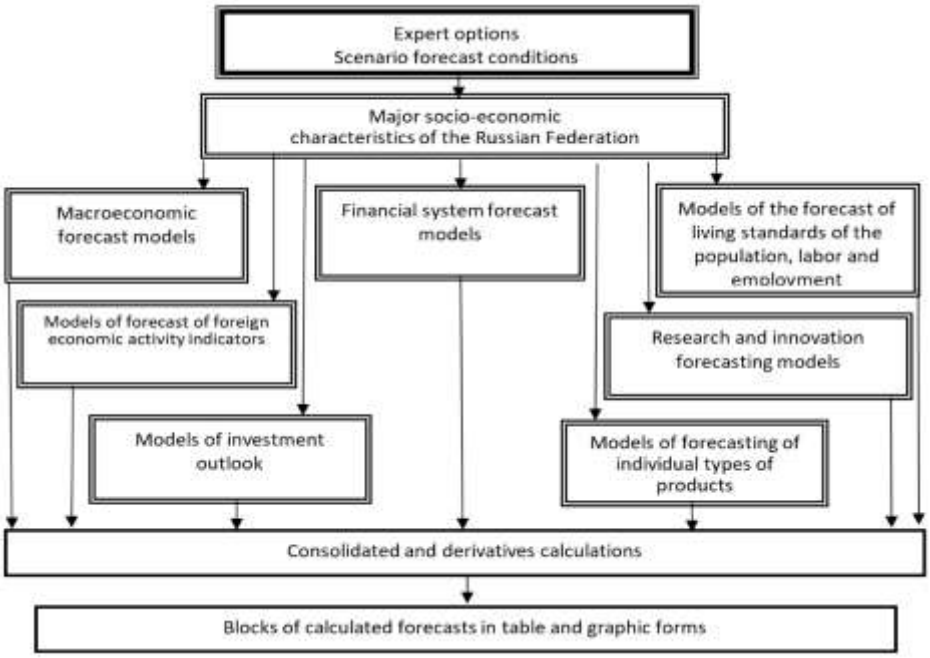

FIGURE 1
CONCEPTUAL SCHEME OF THE SYSTEM OF MODELS FOR SHORT-TERM FORECAST OF INDICATORS OF SOCIO-ECONOMIC DEVELOPMENT OF THE RUSSIAN FEDERATION

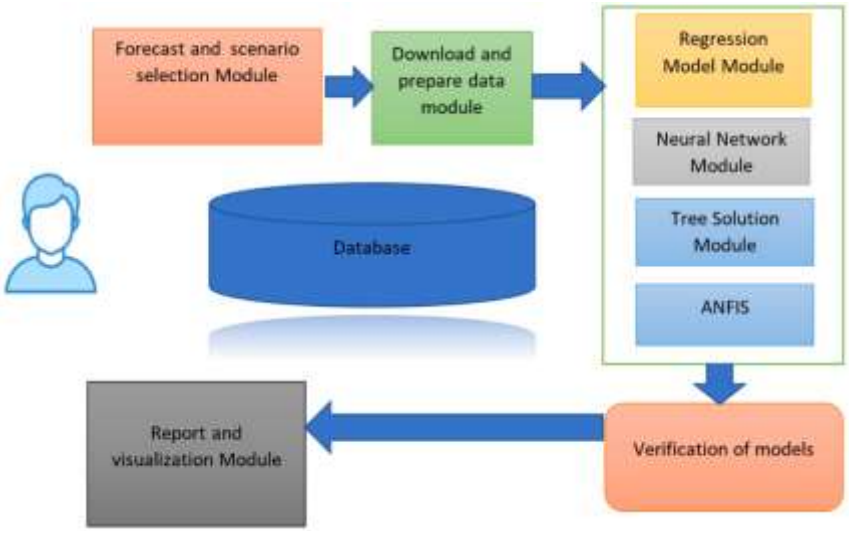

FIGURE 2
COMPONENTS OF THE DIGITAL SERVICE FOR SCENARIO FORECASTING OF SOCIO-ECONOMIC INDICATORS

Due to their specific features, some indicators are difficult to predict using regression models (Kitova, 2016). Therefore, the digital scenario forecasting service is created on the basis of the author's hybrid approach using an ensemble of models, including neural network models

(multi-layer perceptron), decision trees, and the neuro-fuzzy model ANFIS (adaptive neuro-fuzzy inference system).

The digital scenario forecasting service should have the following components (Fig.2): a module for selecting forecast parameters and scenario indicators, a module for automated data loading and preparation, a module for regression equations, a module for neural networks, a module for decision trees, an ANFIS module, a module for model verification (evaluating the quality and accuracy of forecasts), a module for building reports and visualization, as well as a database that stores initial data, intermediate and final results. The digital scenario forecasting service should be open both for connecting new standard blocks of models and expanding the composition of indicators of any model, and for expanding service capabilities in general. Therefore, the service created by the authors has an open microservice architecture that allows you to easily connect new models, methods and groups of indicators, including connecting Python libraries.

The service is developed using C on the DotNet platform (.core), which provides a cross-platform application. PostgreSQL is used as a database management system. The user part of the system is developed as a SPA (Single page application), implemented using React technology (JavaScript framework for creating user interfaces) and bootstrap libraries. Layout and revision of the original templates is carried out using HTML5 and CSS3 technologies.

The necessary requirements for the digital service under development are: its availability for all major browsers (Google Chrome, Yandex Browser, Mozilla Firefox, Opera, Safari) and mobile operating systems Android and iOS, user authorization, the ability to upload reports to Microsoft Office, advanced prompts and educational examples of forecasting. An important requirement is an intuitive interface, simplicity and ease of use by various user groups.

CONCLUSION

The most important goal of Russia is the formation and development of the digital state and the digital economy, the digital transformation of government and business. The article presents the author's view on the need to create and advantages of using a scenario forecasting service for socio-economic indicators of the Russian Federation based on the information and analytical system "SHM Horizon".

Developed by the authors, the information and analytical system "SHM Horizon" allows predicting indicators of socio-economic development of the Russian Federation and regions based on a hybrid model that includes multiple regression and a number of intelligent forecasting models. This system allows you to model the future value of indicators based on scenario conditions set by the expert. The developed adaptive network module based on the ANFIS fuzzy inference system will make the service adaptive and self-learning, which will allow specialists to conduct research without having deep knowledge in the field of programming and machine learning.

When developing a digital service, microservice architecture and modern software engineering technologies are used.

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