

Machine learning methods and models, predictive analytics and applications: development trends in the post-crisis syndrome caused by COVID-19

Lidiya Guryanova¹[0000-0002-2009-1451], Roman Yatsenko² [0000-0001-7968-6890], Nadija Dubrovina³[0000-0003-1346-9708], Vitalina Babenko⁴ [0000-0002-4816-4579], Vitalii Gvozditskyi⁵[0000-0003-4686-267X]

^{1,2,5} Simon Kuznets Kharkiv National University of Economics, Ukraine, guryanovalidiya@gmail.com, roman.yatsenko@hneu.net, gvozdikramm@gmail.com

³School of Economics and Management in Public Administration in Bratislava, University of Economics in Bratislava, Slovakia, nadija@mail.ru

⁴ V. N. Karazin Kharkiv National University, Ukraine, vitalinababenko@karazin.ua

Abstract. This is an introductory text to a collection of articles selected from the MPSESM-XIII conference: Modern Problems of Modelling Socio-Economic Systems, which took place in Kharkov, Ukraine, April 8-9th, 2021. Due to quarantine measures in connection with COVID-19, a number of sections have been working in a mixed (online, offline) mode on the basis of S. Kuznets Kharkiv National University of Economics. The following is a brief overview of the main scientific schools on modelling systems and of the results of their work. Particular attention is paid to the development of economic, financial and other applications based on methods and models of machine learning, predictive analytics in the context of the post-crisis syndrome caused by COVID-19.

Keywords: predictive analytics, machine learning methods, Data Science applications for economics, business, finance, healthcare, education, public administration

1 Introduction

Since 2019, the lives of most people on the planet have changed dramatically due to the COVID-19 pandemic. To ensure high social standards for protecting the life and health of the population, reducing the level of morbidity and mortality, almost all governments have taken unprecedented measures related to limiting social activity, declaring a state of

Copyright © 2021 for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

emergency in certain countries or regions, and constantly monitoring the health status of the population to prevent severe cases of the disease, making restrictions on movement and transferring work into offline mode, etc. Quarantine measures, on the one hand, lead to a significant decrease in the spread of COVID-19 and the stable operation of health systems, and, on the other hand, caused a sharp decline in the level of business activity, disruption of supply chains around the world, panic in stock markets and crisis processes in a number of business areas: tourism, hotel, restaurant business, in the field of air transportation, etc. This, in turn, created the prerequisites for the formation of a "funnel" of the crisis for the rest of the economy.

Due to the differentiated structural dynamics of the economy and social sphere, the degree of countries' sensitivity to the global "shock" induced by COVID-19 is different [1]. This is well demonstrated by the estimates of the depth of the recession in the economic sphere, presented by the International Monetary Fund (IMF). According to IMF estimates, the global economic decline in 2020 was -4.9%. The only major economy in the world to show growth was China. The depth of the recession for the group of countries with a high level of development is estimated at -8% in 2020, followed by a recovery in the level of business activity to 4.8%. For the group of countries with emerging markets, the depth of the recession is -3%, followed by recovery to 5.9% [1-2].

Differentiated sensitivity of countries to the impact of global "shocks", which is manifested in the rate of infection, the duration of the recession, the depth of the recession, the rate of recovery, requires studying the features of the course of crisis socio-economic processes to form an adequate package of anti-crisis measures. Therefore, it is relevant to analyze the asymmetric impact of the COVID-19 "shock" on the dynamics of socio-economic development of different countries in order to form effective proactive strategies.

It should be noted that the problem of assessing the resilience of countries to the impact of the global "shock" was considered in the works of many scientists, experts of system funds, project groups of departments of strategic planning and macroeconomic forecasting [3-11]. So, in works [4-6] the methods of fractal analysis, cluster analysis, Kohonen's neural networks are used to assess the stability of the economy to "shocks". The developments proposed by the authors make it possible to predict the depth of the crisis, to reveal the unidirectional reactions of the national economies of countries of different groups to the action of "shocks". A large number of analytical reviews and works, including works [7-11], are devoted to the development of a consensus forecast of the rate of economic decline and the rate of recovery in the post-crisis period, analysis of changes in the situation on the labor market, employment of various groups of the population, development of economic sectors in the post-crisis period. However, important issues are reviewed not deeply, such as: the issues of assessing the opinions of experts of various focus groups on the effectiveness of quarantine measures and the most effective package of anti-crisis measures, the specifics of the stabilization policy, taking into account the degree of vulnerability of the economy to the action of global "shocks", the issues of the

impact of the global “shock” on political stability, the level of institutional trust, the issues of assessing the potential for recovery of the level of business activity, taking into account the differentiated response of countries to global “shocks”, the issues of social transformations in education, healthcare, etc. in the post-crisis period, which became the main topics for discussion at the MPSESM-XIII conference.

2 MPSESM: development trends of the main scientific schools in the context of the post-crisis COVID-19 syndrome

It must be said that MPSESM is an international scientific and practical conference, which, since 2009, has been bringing together scientists from different countries in the field of problems of developing a model basis for information and analytical management systems. The following basic scientific schools function within the framework of the conference:

Predictive analytics and econometric modelling. The main focus of the research of scientists of this scientific school is modelling the dynamics of financial markets, financial processes, optimization of portfolio and trading strategies, development of adequate models for forecasting the characteristics, state, behavior of systems under conditions of uncertainty and risk, incomplete information, the impact of global "shocks". So, within the framework of this direction, a conceptual approach to the construction of a set of models for assessing the effectiveness of health systems has been proposed, which, based on machine learning methods, makes it possible to form recommendations for choosing a model for the financial development of health systems. The approbation of the model of a comprehensive assessment of the level of resource provision of health care systems on the data of European countries has been carried out. The ranking of countries according to the level of socio-economic efficiency of resource provision of health care systems was obtained.

Special attention is paid to the systems of predictive analytics in the tourism sector, the weakness of the classical methods of analysis and forecasting of the dynamics of resort and recreational systems in the presence of bifurcation points is shown. Models of forecasting and management of processes in the resort and recreational economy have been analyzed and developed to ensure its sustainable functioning and development. The concept of developing a model basis for the dynamics of the resort and recreational system, which is based on the theory of self-organization of the system in conditions of crisis development and resource constraints, is proposed. A model of the evolutionary process of development of the resort and recreational system has been built, the chaotic dynamics of such a system has been investigated, criteria have been developed to assess the location of the system in the zone of intersection of chaos. It is shown that the proposed approach makes it possible to obtain more accurate and universal scenarios for the development of the resort and recreational sphere in conditions of crisis development

in comparison with traditional approaches and to form an adequate package of anti-crisis measures.

The proposed methods for predictive analytics of the value of derivative securities, which are based on calculating the volatility of options with general local stochastic volatility using the methods of the Taylor series for degenerate diffuse processes, in particular for diffusion with inertia, aroused quite a lot of interest. The developed models for assessing the company's market value, which, based on machine learning methods, allow increasing the validity and quality of monitoring and market value management systems in the context of unstable dynamics of financial markets caused by COVID-19, were also recognized as worthy of attention.

Models of assessment and analysis of the development of territories. Within the framework of this scientific school, the focus of research was concentrated on the problem of assessing the effectiveness of public administration mechanisms in the context of the impact of a global "shock". In particular, the most interesting was the work in which the task of assessing the effectiveness of measures taken by governments to overcome the crisis caused by the COVID-19 pandemic was considered. This task is urgent, since governments and international institutions have not determined uniform approaches and rules for state regulation during a pandemic. The varying degrees of restrictions and support measures applied by different governments have led to different results. The developed model basis makes it possible to assess the effectiveness of government decisions by comparing the cost-benefit ratio with the maximum possible value achieved in a group of similar countries. DEA analysis models make it possible to assess the comparative efficiency for European countries based on the ratio of the resources invested – the index of government rigidity or individual policy of restrictions or support, as well as the results – the mortality rate and changes in GDP. The results of the study show that this approach makes it possible to assess the effectiveness of public administration mechanisms and propose directions for their potential improvement.

The study of the possibilities of using machine learning methods to assess interpersonal trust on an individual and social basis and to determine the relationship between an individual's institutional trust and social characteristics aroused considerable interest. Factors that can be viewed as determinants of social trust were identified using classification models (for both interpersonal and institutional trust) and cluster analysis (for trust in government). Classification makes it possible to predict the class (level of confidence) to which the respondent belongs, based on a number of factors (predictors). The best results for interpersonal trust as well as trust in government were obtained in classification models with a mixed set of constituent predictors. Individual and social characteristics were found to be associated with high or low levels of trust in government. The research results can, to a certain extent, be arguments in favor of a multilevel approach to the determinants of social trust, the need to take into account individual and social factors for predictive analysis for both interpersonal and institutional trust.

Methods and Models of Data Science and Machine Learning: Analytical Research in Economics. This scientific school aims to develop management technologies to improve the efficiency of organizations, in particular, in the context of the post-crisis syndrome induced by COVID-19. Within the framework of this scientific school, the following developments were recognized as the most interesting.

A prototype of a public opinion monitoring system on COVID-19 measures using machine learning and sentiment analysis has been proposed, containing: data collection; preliminary data processing and statistical analysis of the created corpus; semantic analysis of the corpus; sentiment analysis. The assessment obtained according to the proposed methodology is confirmed by the results of the survey on the support of government activities on COVID-19. The system is designed as a set of Python and SQL scripts.

The problem of increasing the efficiency of personal training systems in on-line education is considered. A set of knowledge assessment models based on the method of interval repetition and the model of an individual learning trajectory is proposed. The model basis contains blocks of forming a bank of questions, acquiring and forming knowledge, assessing knowledge, improving the quality of the bank of questions. A set of knowledge assessment models is implemented on the basis of a chat bot when preparing applicants for external independent testing in mathematics in Telegram.

The application of machine learning methods for client profitability analysis for non-bank lenders has been investigated. An approach based on joint management of customer profitability and credit risk is considered. The developed clustering models were applied in the construction of recommendation systems and in the development of a strategy for granting loans in the non-banking sector.

The scientific schools presented at the MPSESM-XIII conference have a wide geography and unite scientists from Poland, Slovakia, Bulgaria, Slovenia, Greece, Austria, Lithuania, Great Britain, Ukraine, Russia, Mexico, Canada, and the USA. The institutional environment of the conference was represented by 59 research centers, universities, IT companies (Fig. 1). In particular, such as LLC "MEKHATRONIKA" (Ukraine), INTEGRATED TECHNOLOGY LABORATORY LLC (USA).

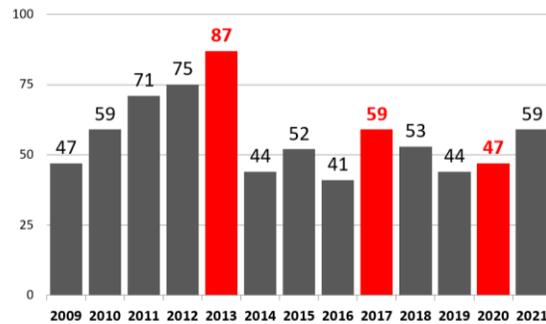


Fig. 1. The number of research centers, universities, IT companies whose representatives took part in MPSESM I-XIII

The submitted papers were double-blind peer-reviewed by the program committee members using the conference management system <http://mpsesm.org/>. 10 selected publications formed the core of this collection of articles.

3 Conclusions

The work of the conference was supported by 164 scientists, including 57 doctors of sciences, 3 corresponding members of the academies of sciences. We thank the participants for interesting reports and look forward to further cooperation in the field of predictive analytics and econometric modelling; modelling the development of territories; modelling of security systems; system analysis and design of decision support systems; modelling financial processes; information technology in business and education; development of reflexive control models; application of machine learning and data science methods for analytical research in economics and business.

References

1. Jones, L., Palumbo, D. & D. Brown (2021). *Coronavirus: How the pandemic has changed the world economy*. *BBC News*. Retrieved from: <https://www.bbc.com/news/business-51706225>.
2. *A Crisis Like No Other, An Uncertain Recovery (2020)*. Retrieved from: <https://www.imf.org/en/Publications/WEO/Issues/2020/06/24/WEOUpdateJune2020>
3. Strelchenko, I., Matviychuk, A., Vashchaiev, S., & H. Velykoivanenko (2019). Simulation of the crisis contagion process between countries with different levels of socio-economic development. *CEUR Workshop Proceedings*. Volume 2393. P. 485-496. URL: http://ceur-ws.org/Vol-2393/paper_423.pdf
4. Strelchenko, I.I. (2020). Forecasting the scenarios of Ukraine's economic development under the influence of the COVID-19 pandemic. *Today's economy: current issues and*

innovative aspects: materials of III International scientific-practical conf., July 25, 2020, Zaporozhye. East Ukrainian Institute of Economics and Management

5. Guryanova, L.S., Zima, A.G. & Polyanskiy, V.A. (2020). Application of cluster and fractal analysis methods to study the dynamics of financial security indicators of stock markets. *System analysis and modelling of management processes*. Ed. by Dr. of Science, Prof. V.S. Ponomarenko, Dr. of Science, Prof. T.S. Klebanova, Dr. of Science, Prof. L.S. Guryanova. Bratislava – Kharkiv, VSHEM – S. Kuznets KNUE. Retrieved from: <http://repository.hneu.edu.ua/handle/123456789/23803>
6. Polyakova, O.Y., Chernova, N.L. (2020). Assessing the resilience of economies during the global economic crisis. Modern problems of modelling of socio-economic systems. *Proceedings of the XII International Scientific and Practical Conference, April 09-10, 2020*. Multimedia scient. electr. publ. Bratislava – Kharkiv, VSHEM – S. Kuznets KNUE. Retrieved from: <http://mpsesm.org/book/2020/thesis02-885.html#thesis02-885>
7. *Ukraine: the impact of COVID-19 on the economy and society (2020)*. Ministry of Economic Development, Trade and Agriculture of Ukraine. Department of Strategic Planning and Macroeconomic Forecasting. August 2020, №52. Retrieved from: <https://www.me.gov.ua/>
8. Fasih, T., Patrinos, H. & M. N. Shafiq (2020). *The Impact of COVID-19 on Labor Market Outcomes: Lessons from Past Economic Crises*. World Bank Blogs. <https://blogs.worldbank.org/education/impact-covid-19-labor-market-outcomes-lessons-past-economic-crises>
9. Gudmundsson, S. V., Cattaneo, M. & R. Redondi (2021). Forecasting temporal world recovery in air transport markets in the presence of large economic shocks: The case of COVID-19. *Journal of Air Transport Management*, Volume 91. <https://doi.org/10.1016/j.jairtraman.2020.102007>
10. Brada, Josef C., Gajewskic, P. & Ali M. Kutande (2021). Economic resiliency and recovery, lessons from the financial crisis for the COVID-19 pandemic: A regional perspective from Central and Eastern Europe. *International Review of Financial Analysis*, Volume 74. <https://doi.org/10.1016/j.irfa.2021.101658>
11. Shinnosuke, Kikuchi, Sagiri. Kitao . & Minamo Mikoshiba (2021). Who suffers from the COVID-19 shocks? Labor market heterogeneity and welfare consequences in Japan. *Journal of the Japanese and International Economies*, Volume 59. <https://doi.org/10.1016/j.jjie.2020.101117>