

# Machine learning for prediction of emergent economy dynamics

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## Abstract

This is an introductory text to a collection of selected papers and revised from the M3E2 2021: 9th International Conference on Monitoring, Modeling & Management of Emergent Economy, which held in Odessa National University of Economics, Odessa, Ukraine, on the May 26-28, 2021. It consists of introduction, conference review and some observations about the event and its future.

## Keywords

dynamics of emergent markets in crisis and post-crisis period, econophysics, global challenges for economic theory and practice in Europe, information systems and technologies in economics, innovation models of economic development, modeling of hospitality sphere development, models of global transformations, monitoring, modeling and forecasting in the banking sector, monitoring, modeling, forecasting and preemption of crisis in socio-economic systems, risk management models in emergent economy

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# 1. Introduction

The development of human society, its various spheres of activity and functioning in recent years is characterized by the emergence of new challenges and threats. Humanity is facing many global problems of development of technology and the increasing scientific and technological progress. In addition to the usual environmental and man-made disasters, financial crises, the new ones appeared. The COVID-19 pandemic, for example. As a result, technologies and online communication instruments began to develop at an increasing pace. The need to work and study remotely has forced people to master new methods and tools of digital technology.

Due to the limited movement and transportation, as well as due to the reduction of production and business closure, enterprises, regions, national economies and transnational capital found themselves in a difficult situation. They experienced a decline in production and trade, bankruptcy, reduced profitability, slower growth etc. This is just a small list of the effects of the pandemic on the world economy.

The causes, mechanisms and consequences of such processes are of particular concern to the scientific community, which is the first to try to understand the depth and importance of these changes. This year's theme of the International Conference on Monitoring, Modeling & Management of Emergent Economy has especially relevant issues that experts of various fields are trying to raise and solve in their works.

The authors' attempt to find out the causes of the crisis and the possibility of using modern ICT to solve existing problems or prevent economic, political and environmental threats, need to be especially considered. The countries with emerging economies are particularly vulnerable to new challenges, so participation in constructive scientific discourse is very important. Modern challenges contribute to the search for new approaches to solving these problems.

In their research scientists focus on economic, financial security and sustainability of enterprises and regions; digitalization of all spheres of human life; modern methods of management and marketing activities; development and analysis of the financial market and cryptocurrency market; modeling and forecasting of international economic activity of various business entities; especially relevant methods of machine learning and fuzzy logic; solving the problems of various sectors of the economy of Ukraine and other countries, especially countries with emerging economies.

The subject of the works included in the proceedings it necessary to search for a new scientific paradigm in a constantly changing environment. After all, new challenges and threats are a certain stimulus for the development of scientific thought. We expect that the research of the participants of this conference will be useful for scientists, teachers, students and representatives of the business community.

## 1.1. M3E2 2021 at a glance

The **Monitoring, Modeling & Management of Emergent Economy** (M3E2, <https://m3e2.ccjournals.eu/2021/>) is a peer-reviewed international conference focusing on research advances and applications of nonlinear dynamics methods, econophysics and complex systems methodology of emergent economy.

The M3E2 Conference occupies contributions in all aspects of Computational Finance, Economics, Risk Management, Statistical Finance, Trading and Market Microstructure, (Deep) Machine Learning technologies and tools, paradigms and models, relevant to modern financial engineering and technological decisions in the modern age. There is urgent general need for principled changes in postclassic economy elicited by current models, tools, services, networks and IT communication.



Figure 1: M3E2 2021 logo.

M3E2 2021 topics of interest since 2019 [1, 2]:

- Complex cyberphysical systems, synergy, econophysics, economy of agents
- Dynamics of emergent markets in crisis and post-crisis period
- Economic security
- Global challenges for economic theory and practice in Europe
- Information systems and technologies in economics
- Innovation models of economic development
- Machine learning for prediction of emergent economy dynamics
- Management of the state's economic safety and economic safety of economic agents
- Methods and models of artificial intelligence in economic systems
- Modeling of hospitality sphere development
- Models of global transformations
- Monitoring, modeling and forecasting in the banking sector
- Monitoring, modeling, forecasting and preemption of crisis in socio-economic systems
- Optimal management of socio-economic processes
- Risk management models in emergent economy

This volume contains the selected and revised papers presented at M3E2 2021: 9th International Conference on Monitoring, Modeling & Management of Emergent Economy held on May 26-28, 2021 in Odessa, Ukraine.

There were 45 submissions. Each submission was reviewed by at least 3, and on the average 3.1, program committee members. 11 papers were accepted for this volume as regular papers.

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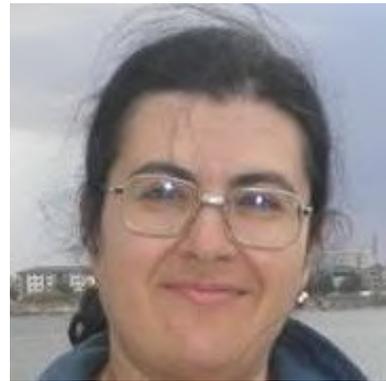
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## 2. Articles overview

The aim of the article “Innovative behavior of bitcoin market agents during COVID-19: recurrence analysis” [3] by Hanna Yu. Kucherova, Vita O. Los, Dmytro V. Ocheretin, Olha V. Bilska and Evgenia V. Makazan (figure 2) is to study the series of the dynamics of the price of bitcoin and the frequency of online requests for bitcoin as an indicator of the behavior of agents of the digital economy using the methods of qualitative recurrent analysis. The types of constructed time series plots of the price of bitcoin and the frequency of requests for bitcoin are defined as drift with a superimposed linearly gradually increasing sequence, which indicates the unpredictability of the behavior of digital economy agents with a gradual stabilization in new quality trend. The scientific novelty of the research results lies in the proven connection between the series of bitcoin price dynamics and the frequency of online requests for bitcoin,

tracking changes in the behavior of digital economy agents before and after the introduction of quarantine restrictions. The procedure for conducting a qualitative recurrence analysis of the series of dynamics is generalized, which takes into account the specifics of the formation of the frequency of online requests for bitcoin, the price and the behavioral aspect of its formation. The practical value lies in defining the characterization of the behavior model of digital economy agents under conditions of quarantine restrictions. The behavior of digital economy agents in the context of COVID-19 requires further research, in particular, using cross-recurrent analysis methods.

This article highlights further research by the authors, begun in [4, 5, 6, 7, 8, 9, 10].



**Figure 2:** Presentation of paper [3].

The article “Comparative analysis of the stock quotes dynamics for IT and the entertainment industry companies based on the characteristics of memory depth” [11] by Nataliia K. Maksyshko and Oksana V. Vasylieva (figure 3) is devoted to the study and comparative analysis of the stock quotes dynamics for the world’s leading companies in the IT sector and the entertainment industry. Today, these areas are developing the fastest and most powerful, which attracts the attention of investors around the world. This is due to the rapid development of digital communication technologies, the growth of intellectualization and individualization of goods and services, and so on. These spheres have strong development potential, but the question to how their companies’ stock quotes respond to the impact of such a natural but crisis phenomenon as the COVID-19 pandemic remains open. Based on the nonlinear paradigm of the financial markets dynamics, the paper considers and conducts a comprehensive fractal analysis of the quotations dynamics for six leading companies (Apple Inc., Tesla Inc., Alphabet Inc., The Walt Disney Company, Sony Corporation, Netflix) in this area before and during the COVID-19 pandemic. As a result of the application of the rescaled range analysis (R/S analysis), the presence of the persistence property and long-term memory in the stock quotes dynamics for all companies and its absence in their time series of profitability was confirmed. The application

of the method of sequential R/S analysis made it possible to construct fuzzy sets of memory depths for the considered time series and to deepen the analysis of the dynamics due to the quantitative characteristics calculated on their basis. Taking into account the characteristics of memory depth in the dynamics of quotations made it possible to conduct a comparative analysis of the dynamics, both under the influence of the natural crisis situation and in terms of investing in different terms. The peculiarities of the delayed profitability dynamics of quotations for each of the companies are also taken into consideration and compared. The developed recommendations can be used in investment activities in the stock market.

This article highlights further research by the authors, begun in [12, 13, 14].

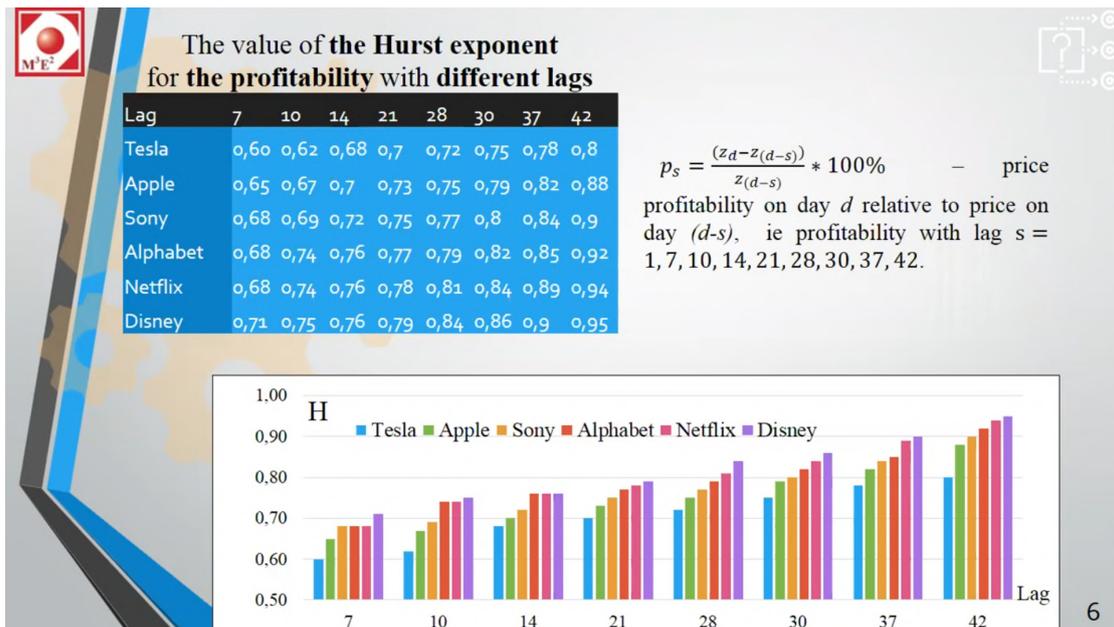
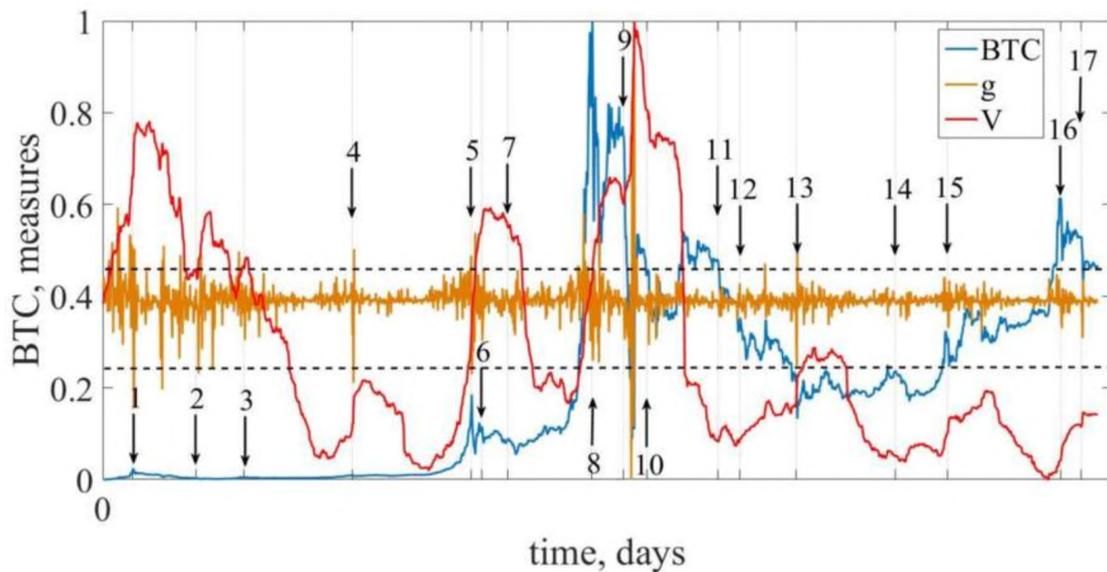


Figure 3: Presentation of paper [11].

Cryptocurrencies refer to a type of digital asset that uses distributed ledger, or blockchain technology to enable a secure transaction. Like other financial assets, they show signs of complex systems built from a large number of nonlinearly interacting constituents, which exhibits collective behavior and, due to an exchange of energy or information with the environment, can easily modify its internal structure and patterns of activity. The article “Econophysics of cryptocurrency crashes: a systematic review” [15] by Andrii O. Bielinskyi (figure 4), Oleksandr A. Serdyuk, Serhiy O. Semerikov and Vladimir N. Soloviev review the econophysics analysis methods and models adopted in or invented for financial time series and their subtle properties, which are applicable to time series in other disciplines. Quantitative measures of complexity have been proposed, classified, and adapted to the cryptocurrency market. Their behavior in the face of critical events and known cryptocurrency market crashes has been analyzed. It has been shown that most of these measures behave characteristically in the periods preceding the critical event. Therefore, it is possible to build indicators-precursors of crisis phenomena in the cryptocurrency market.

This article highlights further research by the authors, begun in [16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33].



**Figure 4:** Presentation of paper [15].

The focus of the article “Irreversibility of financial time series: a case of crisis” [34] by Andrii O. Bielinskyi, Serhii V. Hushko (figure 5), Andriy V. Matviychuk, Oleksandr A. Serdyuk, Serhiy O. Semerikov and Vladimir N. Soloviev to measure the varying irreversibility of stock markets. A fundamental idea of this study is that financial systems are complex and nonlinear systems that are presented to be non-Gaussian fractal and chaotic. Their complexity and different aspects of nonlinear properties, such as time irreversibility, vary over time and for a long-range of scales. Therefore, this work presents approaches to measure the complexity and irreversibility of the time series. To the presented methods authors include Guzik’s index, Porta’s index, Costa’s index, based on complex networks measures, Multiscale time irreversibility index and based on permutation patterns measures. This study presents that the corresponding measures can be used as indicators or indicator-precursors of crisis states in stock markets.

This article highlights further research by the authors, begun in [35, 36, 37].

The article “Big Data based marketing forecasting” [38] by Sergey M. Ivanov and Mykola M. Ivanov (figure 6) discusses the use of big data as a tool to increase data transfer speed while providing access to multidimensional data in the process of forecasting product sales in the market. In this paper discusses modern big data tools that use the MapReduce model. The big data presented in this article is a single, centralized source of information across your entire domain. In the paper also proposes the structure of a marketing analytics system that includes many databases in which transactions are processed in real time. For marketing forecasting of multidimensional data in Matlab, a neural network is considered and built. For training and building a network, it is proposed to construct a matrix of input data for presentation in a neural network and a matrix of target data that determine the output statistical information.



**Figure 5:** Presentation of paper [34].

Input and output data in the neural network is presented in the form of a  $5 \times 10$  matrix, which represents static information about 10 products for five days of the week. The application of the Levenberg-Marquardt algorithm for training a neural network is considered. The results of the neural network training process in Matlab are also presented. The obtained forecasting results are given, which allows us to conclude about the advantages of a neural network in multivariate forecasting in real time.

This article highlights further research by the authors, begun in [39, 40, 41].

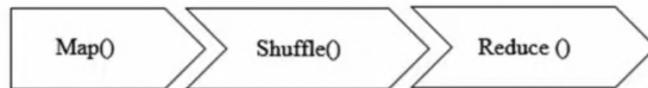
The article “Fuzzy model for complex risk assessment of an enterprise investment project” [42] by Inna I. Chaikovska, Pavlo M. Hryhoruk and Maksym Yu. Chaikovskiy (figure 7) proposes an economic-mathematical model for determining a comprehensive risk assessment of the investment project of the enterprise which are based on the approaches of A. Nedosekin. The model is built using fuzzy logic and takes into account the probability of occurrence of each of the identified risks and the level of impact of each of them on the project. The probability of risk is set by experts in the form of points and converted into linguistic terms, and the level of influence of each of them on the project – the ratio of benefits and is determined using Fishburne scales. The proposed Project Risk Model consists of the following stages: formation of initial data using expert opinions; construction of a hierarchical project risk tree; determination of weight coefficients (Fishburne weights) of project risks; selection and description of membership function and linguistic variables; conversion of input data provided by experts from a score scale into linguistic terms; recognition of qualitative input data on a linguistic scale; determination of a complex indicator of investment project risks; interpretation of a complex indicator. The developed model allows managing the risks of the project to maximize the probability of its successful implementation, to compare alternative projects and choose less risky, to minimize the level of unforeseen costs of the project.

### Main results



**Figure 1:** The importance of management decision making in digital marketing

**Figure 2:** Data processing according to the MapReduce model



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**Figure 6:** Presentation of paper [38].

This article highlights further research by the authors, begun in [43, 44, 45, 46].

The article “Modeling structural changes in the regional economic development of Ukraine during the COVID-19 pandemic” [47] by Pavlo M. Hryhoruk (figure 8), Nila A. Khrushch and Svitlana S. Grygoruk investigates the issues of evaluating structural changes in the regions’ economic development based on the comprehensive index assessment technology. The impact of the COVID-19 pandemic on regional development and changes in the regional structure is considered. The authors propose the use of block convolution to design a comprehensive index based on a set of metric initial indicators that characterize the regions’ economic development. Grouping the set of initial indicators is carried out based on the method of an extreme grouping of parameters and the method of principal components. A weighted linear additive convolution was used to develop partial composite indices and an economic development comprehensive index. The practical approbation was carried out for the regions of Ukraine according to the data of 9 months of 2019 and the same period of 2020. To establish the regions’ structure, authors used the division of the comprehensive index values into intervals and further distributing regions into classes according to the level of economic development. There is a general decrease in the value of the integrated indicator in 2020, caused by the impact of the COVID-19 pandemic. However, no significant changes in the structure of the regions were detected, which indicates an equally negative impact of the pandemic for all regions of Ukraine.

This article highlights further research by the authors, begun in [48].

The article “The use of genetic algorithms for multicriteria optimization of the oil and gas



**Figure 7:** Presentation of paper [42].

enterprises financial stability” [49] by Marta V. Shkvaryliuk, Liliana T. Horal, Inesa M. Khvostina, Natalia I. Yashcheritsyna and Vira I. Shiyko (figure 9) considers the problem of optimizing the financial condition of oil and gas companies. The offered methods of optimization of a financial condition by scientists from different countries are investigated. It is determined that the financial condition of the enterprise depends on the effectiveness of the risk management system of enterprises. It is proved that the enterprises of the oil and gas complex need to develop a system for risk management to ensure the appropriate financial condition. The financial condition is estimated according to the system of certain financial indicators, the integrated indicator of financial condition assessment is constructed using the method of taxonomy. According to the results of the calculation of the integrated indicator, it is concluded that this indicator does not have a stable trend. On the basis of the conducted researches it is offered to carry out optimization of an integral indicator of a financial condition with use of genetic algorithm in the Matlab environment. Based on the obtained results, recommendations of the management of the researched enterprises on increase of management efficiency are given.

This article highlights further research by the authors, begun in [50, 51, 52, 53, 54, 55].

The article “Fuzzy modelling of the country’s migration attractiveness” [56] by Hanna B. Danylchuk, Liubov O. Kibalnyk (figure 10), Oksana A. Kovtun, Oleg I. Pursky and Zenon Sta-



**Figure 8:** Presentation of paper [47].

chowiak deals with the analysis the current state of migration in the context of globalization and identifies the most important corridors for the labour movement. The main donor countries of migrants are developing countries, with low socio-economic indicators, difficult environmental conditions and high levels of poverty. According to forecasts, the most migratory flows will take place in the countries of North America and in Europe, which is due to rising trends in unemployment in the countries of the “third world” and the demand for cheap labour, changes in the structure of the economies of developed countries, changes in labour market demand. The main world regional corridors in 1990–2019 have been identified through statistical analysis. And their growing and declining trends. The need to use economic and mathematical modelling techniques to analyse and determine the migration attractiveness of recipient countries in an uncertain environment has been substantiated. It has been shown that fuzzy logic tools are the most effective in this case. Based on the results of the simulation using the Mamdani method, the world’s attractiveness rating for migration is calculated, which with a “high” thermo leads such countries as Italy, France, United Arab Emirates. The findings suggest that migrants are attracted by countries with the lowest inflation rates, high and average GDP per capita and average or low taxation levels.

This article highlights further research by the authors, begun in [58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69].

In the article “Computational method determining integral risk indicators of regional socio-economic development” [57], Oleg I. Pursky, Tetiana V. Dubovyk, Iryna O. Buchatska, Iryna

Figure 3. The results of multicriteria optimization of oil and gas enterprises financial stability

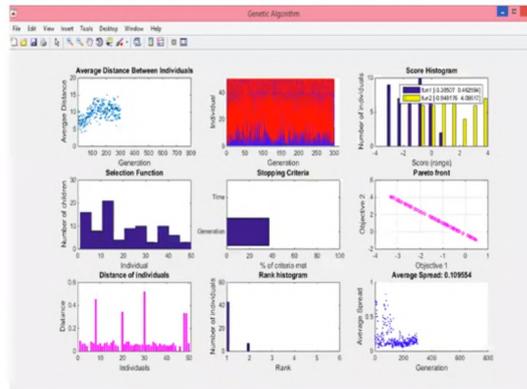


Figure 9: Presentation of paper [49].



Figure 10: Presentation of paper [56].

S. Lutsenko and Hanna B. Danylchuk (figure 11) present the computational method for risk assessment of the socio-economic development of regions. An attempt has been made to develop a method for the determination of integral risk indicators of socio-economic development based on the joint use of the methods of factor analysis and expert evaluation. This approach has



**Figure 11:** Hanna B. Danylchuk, Vita O. Los, Hanna Yu. Kucherova and Liubov O. Kibalnyk after presentation of paper [57].

increased the reliability of the calculations and made it possible to analyze the influence of socio-economic indicators on the risk level of socio-economic development. The integral risk indicator shows the effect of the inconsistency in the level of factor provision on the socio-economic development of the  $j$ -th region (district) in comparison with the general situation in the country (regions). The closer the value of integral risk indicator is to 1, the higher the level of risk in this region. Using Kyiv region districts as an example, the process of risk assessment for regional socio-economic development has been considered. The results obtained in this investigation demonstrate that the presented computational method solves the problem of formalization of risk assessment for the socio-economic development of regions.

The article “Modelling the logistics system of an enterprise producing two type of goods” [70] by Roman V. Ivanov (figure 12), Yuriy V. Sherstennikov, Vasyl M. Porokhnya and Tetyana V. Grynko is devoted to solving the scientific problem of optimizing the retail trade in the production and sale of two types of products, taking into account the change in potential demand for products. The economic and mathematical model of the production activity of the enterprise was developed taking into account logistics and market demand. The logistics scheme takes into account all the main links of the logistics system, as well as the connections between them. The considered scheme makes it possible to take into account the diversification

Case 3. The demand for products of the first type decreases sharply as in the previous case, and for products of the second type remains unchanged. However, the company, foreseeing significant loss of profit, decides to increase the retail network for goods of the first type by 20% in the 300th period.

Find the parameters  $Rm1$ ,  $kR1$ ,  $Rm2$ ,  $kR2$  at which the total net profit reaches its maximum:

$$F(Rm1, kR1, Rm2, kR2) = \sum_{i=1}^T M_i \rightarrow \max.$$

The solution to the optimization problem:

$$\begin{pmatrix} Rm1 \\ kR1 \\ Rm2 \\ kR2 \end{pmatrix} = \begin{pmatrix} 33,6 \\ 1,014 \\ 59,43 \\ 1,043 \end{pmatrix}, \quad F = 2855 \text{ (MU)}$$

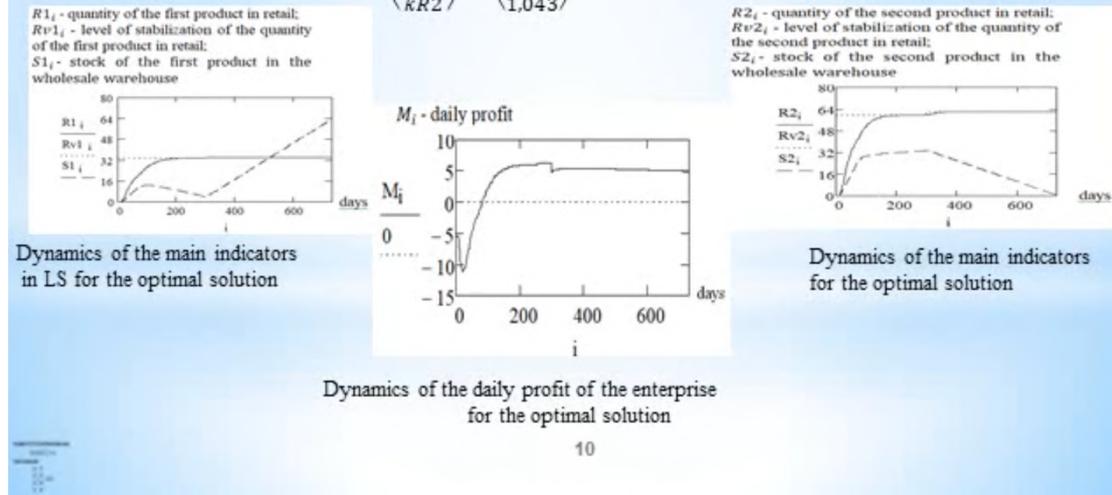


Figure 12: Presentation of paper [70].

of products manufactured by the enterprise. The mathematical model is designed for discrete time. A numerical optimization method has been developed for this mathematical model. The optimal solutions for several cases are found and investigated. The dynamics of the main characteristics of drugs was calculated for all considered cases. A comparative analysis of economic efficiency for the studied cases has been performed. The economic efficiency of retail network optimization is proved.

### 3. Conclusion and outlook

The vision of the M3E2 2021 is provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of emergent economy.

The conference has successfully performing forum to transferring and discussing research result among the researcher, students, government, private sector or industries. Participants and presenters from several countries such as Belarus, China, Czechia, Kazakhstan, Moldova, Poland and Ukraine have attended the conference in-person and online to share their significant



**Figure 13:** Have a nice conference in Odessa, Ukraine!

contribution in research related to Monitoring, Modeling & Management of Emergent Economy.

We are thankful to all the authors who submitted papers and the delegates for their participation and their interest in M3E2 as a platform to share their ideas and innovation. Also, we are also thankful to all the program committee members for providing continuous guidance and efforts taken by peer reviewers contributed to improve the quality of papers provided constructive critical comments, improvements and corrections to the authors are gratefully appreciated for their contribution to the success of the conference. Moreover, we would like to thank the developers and other professional staff of *Not So Easy Science Education* platform (<https://notso.easyscience.education>), who made it possible for us to use the resources of this excellent and comprehensive conference management system, from the call of papers and inviting reviewers, to handling paper submissions, communicating with the authors etc.

We are looking forward to excellent presentations and fruitful discussions, which will broaden our professional horizons. We hope all participants enjoy this conference and meet again in more friendly, hilarious, and happiness of further M3E2 2022.

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