UDC 519.85:(658.7+656)::(37.058+001.8)

Metaheuristic logistic optimization in education &science sector of modern economics in complex & dynamic terms

Svitlana Krasniuk
Kyiv National University of Technologies and Design, Kyiv
https://orcid.org/0000-0002-5987-8681

Abstract. *This study examines metaheuristic logistic optimization in the education and R&D sectors under uncertainty and dynamic complexity. Traditional optimization methods often fail in such conditions, while metaheuristic algorithms (genetic algorithms, particle swarm optimization, simulated annealing, and hybrid approaches) offer flexible tools for solving multidimensional and multi-criteria problems. Their adaptability and scalability enable efficient resource allocation, scheduling, project prioritization, and information flow management. The integration of metaheuristics supports intelligent management systems, improves decision-making, and enhances efficiency in rapidly changing environments.*
Keywords*: metaheuristic optimization, logistics, education, R&D.*

Introduction.

Modern management is faced with the need to make decisions in conditions of significant uncertainty [1, 2], rapid changes in the external environment [3], and the complexity of organizational processes. Currently, organizations and institutions operate in the context of globalization, rapid technological development, high instability of the competitive environment [4], and finally, in conditions of crises of various levels, scales, and etiologies [5, 6] - which leads to the emergence of extremely complex logistics management tasks (in particular for the education and R&D industries/sectors).

Such logistics systems in the above conditions synergistically encompass numerous interconnected elements - suppliers, warehouses, transport networks, customers, and production units, etc. [7]. Fluctuations in demand, resource availability, transport conditions, and prices form a dynamic logistics environment [8], [9], where traditional optimization methods often prove ineffective due to the need for accurate mathematical modeling and stability of parameters [10], [11]. It is in such complex conditions that metaheuristic optimization is an effective and powerful technology for optimal management of logistics processes, capable of flexibly adapting to changes and finding solutions close to optimal ones even in cases of multi-criteria and stochastic problems [12], [13]. Metaheuristic optimization synergistically integrates elements of random search, evolutionary selection and local optimization [14, 15], which allows finding solutions close to optimal ones even in complex and stochastic systems [16]. Due to their high flexibility, scalability and ability to quickly adapt to changes [17, 18], metaheuristics effectively support the management of delivery routes, inventories,

resource allocation and planning of production operations. Their main advantage is the ability to work with large amounts of data, take into account incomplete information and quickly respond to changes in the external environment [19, 20]. Thus, the application of metaheuristic approaches opens up new prospects for strategic and operational logistics management in conditions of uncertainty and crises.

The Main Part.

The modern education sector and the field of research and development (R&D) projects are characterized by extreme complexity, high dynamism and the presence of significant uncertainty. Organizing an effective educational process, managing resources and planning scientific research in such conditions is becoming an increasingly difficult task. The growth of data volumes, the increase in the number of process participants and the growing need for high-precision solutions impose new requirements on optimization methods.

Metaheuristic algorithms, including genetic algorithms, particle swarm optimization (PSO) algorithms, simulated annealing, as well as combined hybrid modelling [21] for optimization - are the powerful tool for effectively solving complex multidimensional problems. They are able to find high-quality approximate solutions even in the case of limited or incomplete information and a significant number of choice options. This makes them especially relevant for managing complex processes in education and R&D, where logistical, financial, organizational and informational aspects are combined.

Areas of application of metaheuristic optimization in education and R&D: management of educational and research resources: planning of lesson schedules, distribution of teachers and scientific supervisors, optimization of the use of classrooms, laboratories and equipment; allocation of financial and material resources: formation of investment strategies in educational programs and scientific projects, ensuring effective use of the budget; optimization of scientific and research projects: determination of task priorities, distribution of work between teams, reduction of project execution time and increase of productivity of scientific groups; management of information flows: optimization of data processing, storage and transmission processes, integration of digital platforms and electronic resources to increase accessibility and efficiency of training and research.

Advantages of using metaheuristics in education and R&D: possibility of effective solution of multi-criteria and complex tasks; search for high-quality approximate solutions in systems with a large number of variables and constraints; adaptability to changes in the external environment and unpredictable conditions; integration with classical optimization methods to obtain hybrid, more stable solutions.

Conclusions.

1. Metaheuristic logistics optimization demonstrates high efficiency in solving complex management problems, where classical methods cannot provide sufficient

flexibility and speed of decision-making. It allows to adapt logistics processes to changing environmental conditions, while optimizing economic, time and resource indicators. The flexibility and versatility of metaheuristic methods make them promising for integration into intelligent management systems and strategic planning.

Among the main advantages of the metaheuristic approach are the ability to process large and heterogeneous data, effective solution of NP-hard problems, the possibility of integration with classical methods to increase the accuracy of results and conduct multi-criteria analysis of the effectiveness of logistics solutions. This makes such approaches an integral part of modern intelligent management and planning in conditions of complexity and dynamics.

2. Metaheuristic logistic optimization is becoming a critically important tool for ensuring effective process management in education and research. The application of metaheuristic methods in education and R&D logistics opens up prospects for integrating various resources, optimizing internal processes and improving the quality of management decisions. This creates the basis for the development of intelligent management systems that can function effectively in conditions of complexity, uncertainty and rapid change.

References

1. Nevmerzhytska S. M. (2018). Formation of a strategy for the innovative development of enterprises in conditions of uncertainty. *Scientific Bulletin of the Kherson State University. Series: Economic Sciences.* 2018. Vol. 32. pp. 99-103. URL: https://ej.journal.kspu.edu/index.php/ej/article/view/422/418.

2. Karpenko, Oksana & Kravchenko, Olha & Palyvoda, Olena & Semenova, Svitlana. (2025). Evaluating the effectiveness of innovation implementation at transport enterprises under conditions of uncertainty. *Academy Review,* #2. 75-88. 10.32342/3041-2137-2025-2-63-5.

3. Palyvoda, Olena & Semenchuk, Tetiana & Rachkovskyy, Eduard. (2024). Modelling growth strategies of transport enterprises in the conditions of context uncertainty. *Baltic Journal of Economic Studies*. 10. 255-267. 10.30525/2256-0742/2024-10-3-255-267.

4. Гращенко І.С., Прищепа Н.П. Формування конкурентного потенціалу підприємств за умов зростання міжнародної конкуренції. *Східна Європа: економіка, бізнес та управління*. 2016. № 4. С. 118–122

5. Naumenko, M. (2024). Methodology of determining factors of activity efficiency and competitive position of the enterprise on the market in crisis conditions. *Scientific innovations and advanced technologies*, № 7(35) (2024). DOI: https://doi.org/10.52058/2786-5274-2024-7(35)-648-665 [in Ukrainian].

6. Tsalko T. R., Nevmerzhytska S.M. (2023) Risk assessment in innovative activity. *Actual problems in economics, finance and management: materials of the*

International Scientific and Practical Conference. East European Center for Scientific Research (Odesa, 25 october 2023). Research Europe, 2023. pp. 92-94 https://research europe.org/product/book-31 [in Ukrainian].

7. Krasnyuk, M., Hrashchenko, I., Krasniuk, S., Kustarovskiy, O. (2019). Reengineering of a Logistic Company and its Information System Taking into Account Macroeconomic Crisis, *Modern Economics*, 13, pp. 141–153.

8. Hrashchenko Iryna, Krasnyuk Maxim, Krasniuk Svitlana (2020). Iterative methodology of bankruptcy forecast of logistic companies in emerging markets, taking into account global/regional crisis. *Collection of scientific works Problems of the systemic approach in economics*, 2020, vol. 1(75), pp. 138-147.

9. Краснюк М.Т., Кустаровський О.Д. Дослідження, адаптація методик і вдосконалення моделей фінансового аналізу підприємств транспортної галузі в поточних кризових умовах України. *Моделювання та інформаційні системи в економіці*. 2017. Вип. 93. С. 175–195.

10. Науменко, М., & Краснюк, М. (2024). Ефективне застосування генетичних алгоритмів у вирішенні багатоекстремумних оптимізаційних задач в менеджменті конкурентного підприємства. *Grail of Science*, (41), 65–73. https://doi.org/10.36074/grail-of-science.05.07.2024.008

11. Kulynych Y., Krasnyuk M., Krasniuk S. (2022). Efficiency of evolutionary algorithms in solving optimization problems on the example of the fintech industry. *Grail of Science*, №14-15, May 2022. 63-70. https://doi.org/10.36074/grail-of-science.27.05.2022.

12. Kulynych Y., Krasnyuk M., Krasniuk S. (2022). Efficiency of evolutionary algorithms in solving optimization problems on the example of the fintech industry. *Grail of Science*, №14-15, May 2022. 63-70. https://doi.org/10.36074/grail-of-science.27.05.2022.

13. Краснюк М.Т., Тішков Б.О., Устенко С.В., Мозгаллі О.П., Галузинський Г.П., Кривошеєв К.В. (2025). Гібридизація еволюційних обчислень у гнучких когнітивних інформаційних управляючих системах в умовах кризи. *Наука і техніка сьогодні,* №4 (45) 2025. С. 1179-1203.

14. Chen, K., Xue, B., Zhang, M., & Zhou, F. (2021). Evolutionary multitasking for feature selection in high-dimensional classification via particle swarm optimization. *IEEE Transactions on Evolutionary Computation*, 26(3), 446-460.

15. Qiao K. et al. An evolutionary multitasking optimization framework for constrained multiobjective optimization problems // *IEEE Transactions on Evolutionary Computation*. – 2022. – Т. 26. – №. 2. – С. 263-277.

16. Tan K. C., Feng L., Jiang M. Evolutionary transfer optimization-a new frontier in evolutionary computation research // *IEEE Computational Intelligence Magazine*. – 2021. – Т. 16. – №. 1. – С. 22-33.

17. Telikani A. et al. Evolutionary machine learning: A survey // *ACM Computing Surveys* (CSUR). – 2021. – Т. 54. – №. 8. – С. 1-35.

18. Liang J. et al. A survey on evolutionary constrained multiobjective optimization // *IEEE Transactions on Evolutionary Computation*. – 2022. – Т. 27. – №. 2. – С. 201-221.

19. Zhan Z. H. et al. A survey on evolutionary computation for complex continuous optimization // *Artificial Intelligence Review*. – 2022. – Т. 55. – №. 1. – С. 59-110.

20. Song, Z., Wang, H., He, C., & Jin, Y. (2021). A kriging-assisted two-archive evolutionary algorithm for expensive many-objective optimization. *IEEE Transactions on Evolutionary Computation*, 25(6), 1013-1027.

21. Krasnyuk, M. (2014). Hybridization of intelligent methods of business data analysis (anomaly detection mode) as a standard tool of corporate audit. *The state and prospects of the development Education and science of today:* materials of the III International science and practice conf. [m. Ternopil, October 10-11. 2014]. TNEU, 2014. pp. 211-212 [in Ukrainian].

UDC 339.138

Peculiarities of marketing activities in modern conditions

Viktoria Systuk
Ivan Franko National University of Lviv, Lviv
https://orcid.org/0009-0002-8638-4692

Abstract. *The modern economy is changing rapidly, forcing businesses to adapt their strategies to new challenges. Marketing is no longer just a sales tool, but a key element of management. A comprehensive approach to marketing activities includes market analysis, brand management, digital tools, and building long-term relationships with consumers, which is especially relevant for Ukrainian companies.*
Keywords: *marketing, marketing activities, digital technologies, strategy.*

Особливості маркетингової діяльності в сучасних умовах

Вікторія Систук
Львівський національний
університет імені Івана Франка, м. Львів
https://orcid.org/0009-0002-8638-4692

Анотація. *Сучасна економіка швидко змінюється, що змушує підприємства адаптувати свої стратегії до нових викликів. Маркетинг уже не лише інструмент збуту, а ключовий елемент управління. Комплексний підхід до маркетингової діяльності охоплює аналіз ринку, бренд-менеджмент, цифрові інструменти та побудову довготривалих стосунків зі споживачами, що особливо актуально для українських компаній.*
Ключові слова: *маркетинг, маркетингова діяльність, цифрові технології, стратегія.*