ABSTRACT AND REFERENCES
CONTROL PROCESSES

DOI: 10.15587/1729-4061.2018.132596

DEVELOPMENT OF THE METHOD FOR THE OPTIMAL MANAGEMENT OF OCCUPATIONAL RISKS (p. 6-13)

Andrew Bochkovskyi
Odessa National Polytechnic University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-4166-3148

Viktor Gogunskii
Odessa National Polytechnic University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-9115-2346

Within the framework of this research, we analyzed international normative and legal documents on risk management in the field of occupational health and safety and identified the following shortcomings:

– uncertainty of the aims of risk management;

– complexity of performance of the appropriate procedure and its insufficient substantiation;

– lack of available approaches to possibility of the optimal risk management, taking into consideration resource capacities of the business entity.

It was noted that one of the main ways of occupational risks management is the reallocation of financial resources of an enterprise. However, based on the result of the analysis, the available methodological tools for implementation of this method were not detected.

To solve this relevant problem, the method for optimal management of occupational risks was developed. The method was developed based on construction of the optimization models, based on the criteria of minimization of average estimated total costs of an enterprise for occupational safety and health. It was noted that harmful production factors operate with random intensity within the working zone over a period of time. And the risk is measured by the probability of exceeding permissible concentrations (levels) of certain factors, which operate in the workspace, as well as with relevant consequences. The variables of the developed models are costs of an enterprise for measures, related to ensuring safe and healthy working conditions.

Direct and inverse optimization problems were stated that were reduced to certain problems of convex programming. The direct problem is to minimize probability of a risk event at the assigned constraint for total costs of occupational safety and health. The reverse problem is how to minimize the average costs for prevention and elimination of consequences of the risk of exceeding permissible concentration at constraint for probability of such excess.

Calculation of the models identified dependence, which is expressed in a decrease in permissible probability of a risk event at an increase in costs of occupational safety and health. This makes it possible to recommend them for using by business entities in the international format.

Keywords: occupational risk, occupational health, risk management, convex programming, occupational diseases.

References

1. Directive No. 89/391 / EEC of the Council on the introduction of measures to improve the safety and health of workers in the workplace** (2008). Verkhovna Rada Ukrainy. Available at: http://zakon3.rada.gov.ua/laws/show/994_b23
2. Gogunskii, V., Bochkovskii, A., Moskaliuk, A., Kolesnikov, O., Babiuk, S. (2017). Developing a system for the initiation of projects using a Markov chain. Eastern-European Journal of Enterprise Technologies, 1 (3 (85)), 25–32. doi: 10.15587/1729-4061.2017.90971
3. Świątkowska, B. (2013). Legal aspects of workers' health protection against asbestos in Poland in the light of the EU legal framework. Medycyna Pracy, 64 (5), 689–697. doi: 10.13075/mp.5893.2013.0057
4. Bochkovskyi, A. P., Sapozhnikova, N. Yu., Gogunskii, V. D. (2017). Legal and organizational issues of improving the labor protection and industrial safety level at the Ukrainian enterprises. Scientific Bulletin of National Mining University, 5 (161), 100–108 doi: 10.13140/rg.2.2.33613.23528
5. Kudryavtsev, S. S., Yemelin, P. V., Yemelina, N. K. (2018). The Development of a Risk Management System in the Field of Industrial Safety in the Republic of Kazakhstan. Safety and Health at Work, 9 (1), 30–41. doi: 10.1016/j.shaw.2017.06.003
6. Fox, M. A., Spicer, K., Chosewood, L. C., Susi, P., Johns, D. O., Dotson, G. S. (2018). Implications of applying cumulative risk assessment to the workplace. Environment International, 115, 230–238. doi: 10.1016/j.envint.2018.03.026
7. Anttonen, H., Pääkkönen, R. (2010). Risk Assessment in Finland: Theory and Practice. Safety and Health at Work, 1 (1), 1–10. doi: 10.5491/shaw.2010.1.1.1
8. Villa, V., Paltrinieri, N., Khan, F., Cozzani, V. (2016). Towards dynamic risk analysis: A review of the risk assessment approach and its limitations in the chemical process industry. Safety Science, 89, 77–93. doi: 10.1016/j.ssci.2016.06.002
9. Rudenko, S. V., Postan, M. Ya. (2011). Metod optimizacii zatrat na prirodoohrannye meropriyatiya pri sluchaynoy intensivnosti zagryazneniya predpriyatiem okruzhayushchey sredy [The method of optimization of costs for environmental protection measures with a random intensity of pollution by the enterprise environment]. Metody ta zasoby upravlinnia rozvytkom transportnykh system, 17, 140–149.
10. Khan, F., Hashemi, S. J., Paltrinieri, N., Amyotte, P., Cozzani, V., Reniers, G. (2016). Dynamic risk management: a contemporary approach to process safety management. Current Opinion in Chemical Engineering, 14, 9–17. doi: 10.1016/j.coche.2016.07.006
11. Khan, F., Rathnayaka, S., Ahmed, S. (2015). Methods and models in process safety and risk management: Past, present and future. Process Safety and Environmental Protection, 98, 116–147. doi: 10.1016/j.psep.2015.07.005
12. Jain, P., Pasman, H. J., Waldram, S., Pistikopoulos, E. N., Mannan, M. S. (2018). Process Resilience Analysis Framework (PRAF): A systems approach for improved risk and safety man-

agement. Journal of Loss Prevention in the Process Industries, 53, 61–73. doi: 10.1016/j.jlp.2017.08.006
13. Zhao, J., Huang, H., Li, Y., Jomaas, G., Wang, H., Zhong, M. (2017). Quantitative risk assessment of continuous liquid spill fires based on spread and burning behaviours. Applied Thermal Engineering, 126, 500–506. doi: 10.1016/j.applthermaleng.2017.07.187
14. The basic statistical data is shown by the economical analytics of the customs agencies EU Countries. Available at: http://ec.europa.eu/eurostat/search?p_auth=QPejFti6&p_p_id=estatsearchportlet_WAR_estatsearchportlet&p_p_lifecycle=1&p_p_state=maximized&p_p_mode=view&_estatsearchportlet_WAR_estatsearchportlet_text=Eurostatistics+DATA+FOR+SHORT-TERM+ECONOMIC+ANALYSIS&_estatsearchportlet_WAR_estatsearchportlet_sort=_score&_estatsearchportlet_WAR_estatsearchportlet_action=search&_estatsearchportlet_WAR_estatsearchportlet_pageNumber=3
15. Bochkovskyi, A. P. (2016). Teoretychni aspekty universalizatsiyi otsinky profesiynoho ryzyku v systemakh upravlinnya okhoronoyu pratsi [Theoretical aspects of univarsalization of professional risk evolution in occupational health and management systems]. Bulletin of the Lviv State University of Life Safety, 14, 134–151. doi: 10.13140/rg.2.2.22043.87848
16. Plotnikov, A. V., Komleva, T. A., Plotnikova, L. I. (2010). The partial averaging of differential inclusions with fuzzy right-hand side. Journal of Advanced Research in Dynamical and Control Systems, 2 (2), 26–34. Available at: https://www.researchgate.net/publication/285992864_The_partial_averaging_of_differential_inclusions_with_fuzzy_right-hand_side
17. Otradskaya, T., Gogunsky, V. (2016). Development process models for evaluation of performance of the educational establishments. Eastern-European Journal of Enterprise Technologies, 3 (3 (81)), 12–22. doi: 10.15587/1729-4061.2016.66562

DOI: 10.15587/1729-4061.2018.131459

A COMPARATIVE ANALYSIS OF THE ASSESSMENT RESULTS OF THE COMPETENCE OF TECHNICAL EXPERTS BY METHODS OF ANALYTIC HIERARCHY PROCESS AND WITH USING THE RASCH MODEL (p. 14-21)

Oleh Velychko
State Enterprise "All-Ukrainian State Scientific and Production Centre for Standardization, Metrology, Certification and Protection of Consumer", (SE "Ukrmetrteststandard"), Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-6564-4144

Tetyana Gordiyenko
Odessa State Academy of Technical Regulation and Quality, Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-0324-9672

Known scales (criteria) for assessing the competence of experts in the field of technical regulation using the method of analytical hierarchy process (AHP) and Rasch model are investigated. The main features of constructing the mathematical Rash model are presented. The results of the analysis of scales for assessing the competence of experts in the field of technical regulation on a specific example of questioned specialists in measurement of time and frequency were considered. The results were processed using the specialized software "Competence MAI 1.1" (Ukraine) and MINISTEP 4.0.1 (USA).

A comparative analysis of the results was carried out in order to determine the effectiveness of the assessment scales. The obtained results showed the possibility of applying the Rasch model for the analysis of the scale of expert assessment in the field of technical regulation. The analysis of the results obtained on the multidimensional Rasch model showed that the chosen criteria scale for experts corresponds to the requirements set by the Rash model. The obtained measurement data for this model allow you to calculate the established statistics for both the criteria and for the evaluated experts.

A comparative analysis of the results obtained with the use of AHP and Rasch model showed convergence, suitability and correlation of the obtained values for experts. Only two out of twenty one (9.5 %) evaluated experts have data that are unsuitable for the analysis by the Rasch model, which indicates a low level of competence. AHP to a lesser extent allows for the consideration of less competent experts than with the use of the Rash model. This is evidenced by a lower coefficient of competence for the AHP than in the application of the Rasch model. AHP and Rasch model should be used in various fields of activity as a useful tool for comparative assessment of the competence of technical experts on the basis of objective data according to established criteria.

Keywords: analytical hierarchy, Rasch model, characteristic curve, competence of experts, scale of evaluation, software.

References

1. Velychko, O. M., Gordiyenko, T. B., Kolomiets, L. V. (2015). Methodologies of expert's competence evaluation and group expert evaluation. Metallurgical and Mining Industry, 2, 262–271.
2. Velychko, O., Gordiyenko, T. (2015). Evaluation of competence of the experts in field of metrology and instrumentations. XXI IMEKO World Congress "Measurement in research and industry". Prague, Czech Republic, 5.
3. Velychko, O. N., Gordienko, T. B., Karpenko, S. R., Kolomiets, L. V. (2016). Evaluation of experts competence on the measurement of electrical power using the method of analytic hierarchy. Metallurgical and Mining Industry, 11, 70–76.
4. Velychko, O., Gordiyenko, T., Kolomiets, L. (2017). A comparative analysis of the assessment results of the competence of technical experts by different methods. Eastern-European Journal of Enterprise Technologies, 4 (3 (88)), 4–10. doi: 10.15587/1729-4061.2017.106825
5. Velychko, O., Gordiyenko, T., Kolomiets, L. (2017). A comparative analysis of results of the group expert assessment of metrological assurance of measurements. Eastern-European Journal of Enterprise Technologies, 6 (9 (90)), 30–37. doi: 10.15587/1729-4061.2017.114468
6. Saaty, T. L. (1992). The Hierarchon: A Dictionary of Hierarchies. Pittsburgh, Pennsylvania: RWS Publications, 510.
7. Saati, T. L. (2008). Prinyatie resheniy pri zavisimostyah i obratnyh svyazyah: Analiticheskie seti. Moscow: Izd-vo LKI, 360.
8. Drake, P. R. (1998). Using the Analytic Hierarchy Process in Engineering Education. International Journal of Engineering Education, 14 (3), 191–196.

9. Chernysheva, T. Yu. (2009). Ierarhicheskaya model' ocenki i otbora ekspertov. Doklady TUSUR. Upravleniya, vychislitel'naya tekhnika i informatika, 1 (19), 168–173.
10. Kolpakova, T. A. (2011). Opredelenie kompetentnosti ekspertov pri prinyatii gruppovyh resheniy. Radioelektronika, informatyka, upravlinnia, 1, 40–43.
11. Kalinina, I. O., Hozhyi, O. P., Musenko, H. O. (2013). Vrakhuvannia kompetentnosti ekspertiv u metodakh bahatokryterialnoho analizu v zadachakh ratsionalnoho vyboru. Nauk. pratsi Chornomor. derzh. univer. Kompiuterni tekhnolohiyi, 191 (179), 116–123.
12. Bhushan, N. (2004). Strategic Decision Making: Applying the Analytic Hierarchy Process. London: Springer-Verlag, 170. doi: 10.1007/b97668
13. Rasch, G. (1960). Probabilistic models for some intelligence and attainment tests. Copenhagen: Danish Institution for Educational Research, 199.
14. Andrich, D. (1988). Rasch models for measurement. Newbury Park CA: Sage, 95. doi: 10.4135/9781412985598
15. Bond, T. G., Fox, C. M. (2007). Applying the Rasch model: fundamental measurement in the human sciences. 2nd ed. Psychology Press, 360. doi: 10.4324/9781410614575
16. Hagquist, C., Bruce, M., Gustavsson, J. P. (2009). Using the Rasch model in nursing research: An introduction and illustrative example. International Journal of Nursing Studies, 46 (3), 380–393. doi: 10.1016/j.ijnurstu.2008.10.007
17. Ehlan, A. H., Kucukdeveci, A. A., Tennant, A. (2010). The Rasch Measurement Model. Research Issues in Physical & Rehabilitation Medicine. Pavia: Maugeri Foundation, 89–102.
18. Demenchenok, O. G. (2010). Matematicheskie osnovy Rasch Measurement. Pedagogicheskie izmereniya, 1.
19. Wright, B. D., Linacre, J. M. (1987). A measurement is the quantification of a specifically defined comparison. Rasch model derived from objectivity. Rasch Measurement Transactions, 1 (1), 4–5.
20. A User's Guide to WINSTEPS®MINISTEP Rasch-Model Computer Programs. Program Manual 4.0.0 by John M. Linacre (2017).
21. Rasch Model/Rasch Analysis: Definition, Examples. Statistics How To. Available at: http://www.statisticshowto.com/rasch-model
22. Communication Validity and Rating Scales. Institute for Objective Measurement. Available at: http://www.rasch.org/rmt/rmt101k.htm
23. Velychko, O., Gordiyenko, T. (2016). The evaluation of activity of Technical Committees of Standardization for Metrology and Measurement on national level. Journal of Physics: Conference Series, 772, 012007. doi: 10.1088/1742-6596/772/1/012007

DOI: 10.15587/1729-4061.2018.133607

DEVELOPMENT OF THE METHOD OF EXPOSURE CONTROL OF GRAIN DRYING IN HIGH-TEMPERATURE DRYERS (p. 22-29)

Mikhail Volkhonov
Federal State Budget Educational Institution of Higher Education "Kostroma State Agricultural Academy"
FGBOU VO Kostroma State Agricultural Academy,
Kostroma Region, Karavaevo Village, Russia
ORCID: http://orcid.org/0000-0003-0332-8848

Igor Jabbarov
Federal State Budget Educational Institution of Higher Education "Kostroma State Agricultural Academy"
FGBOU VO Kostroma State Agricultural Academy,
Kostroma Region, Karavaevo Village, Russia
ORCID: http://orcid.org/0000-0001-5843-5144

Valery Soldatov
Federal State Budget Educational Institution of Higher Education "Kostroma State Agricultural Academy"
FGBOU VO Kostroma State Agricultural Academy,
Kostroma Region, Karavaevo Village, Russia
ORCID: http://orcid.org/0000-0003-3084-0281

Ivan Smirnov
Federal State Budget Educational Institution of Higher Education "Kostroma State Agricultural Academy"
FGBOU VO Kostroma State Agricultural Academy,
Kostroma Region, Karavaevo Village, Russia
ORCID: http://orcid.org/0000-0003-4113-6126

When studying the kinetics of high-temperature wheat drying, it is found that at the end of the constant drying period, there is a sharp increase in the grain heating temperature. The temperature jump occurs due to the grain surface dehydration, when the average relative moisture is close to standard and makes 15...16 %. Based on this regularity, the method of exposure control of grain drying in high-temperature dryers without using continuous-flow moisture meters is developed.

The method is based on simultaneous control of the material heating temperature by temperature sensors over the entire length of the drying chamber. The measured values from the temperature sensors are transmitted to the microcontroller in order to periodically approximate them with the cubic polynomial and find the derivative of the second-order function.

The microcontroller is programmed to determine the second-order critical point – the location of the grain, having standard moisture. The obtained result is compared with the maximum length of the grain path along the drying chamber in order to subsequently influence the discharger performance.

The developed method of exposure control of grain drying in high-temperature dryers provides the necessary time for the temperature effect of the drying agent on the grain, process quality and reduction of energy consumption for grain drying. On the basis of this method, the drying process without the use of expensive continuous-flow grain moisture meters operating with a high measurement error is automated.

Keywords: grain drying, drying control, drying exposure, drying kinetics.

References

1. Wheat production in the world. Countries producing wheat. Available at: http://ab-centre.ru/page/proizvodstvo-pshenicy-v-mire-strany-proizvoditeli-pshenicy
2. Information on holding a conference in Anapa, Krasnodar Territory on June 11-15, 2012. Available at: http://www.drying-committee.ru/dl.php?f=203
3. RUSSIA IN FIGURES. 2017, responsible for the issue: N. S. Bugakova I. V. Voronina T. A. Mikhailova, Brief statistical compilation, June 30, 2017, Printed in the printing house "August Borg" 107497, Moscow, ul. Amurskaya, 5, p. 2.

4. Perfection of the constructions of active ventilation bins. Available at: http://kgau.ru/new/all/konferenc/konferenc/2009/50.doc%D1%97
5. Krichevsky, E. S., Benzar, V. K., Venediktov, M. V. et. al.; Krichevsky, E. S. (Ed.) (1980). Theory and practice of rapid moisture control of solid and liquid materials. Moscow: Energy, 240.
6. Fundamentals of grain drying. Available at: http://www.knowledgebank.irri.org/step-by-step-production/postharvest/drying/drying-basics/drying-process/fundamentals-of-grain-drying
7. Morais, S. J. da S., Devilla, I. A., Ferreira, D. A., Teixeira, I. R. (2013). Modelagem matemática das curvas de secagem e coeficiente de difusão de grãos de feijão-caupi (Vigna unguiculata (L.) Walp.). Revista Ciência Agronômica, 44 (3), 455–463. doi: 10.1590/s1806-66902013000300006
8. Coradi, P. C., Fernandes, C. H. P., Helmich, J. C. (2016). Adjustment of mathematical models and quality of soybean grains in the drying with high temperatures. Revista Brasileira de Engenharia Agrícola e Ambiental, 20 (4), 385–392. doi: 10.1590/1807-1929/agriambi.v20n4p385-392
9. Volgusheva, N. V. (2016). Kinetics of drying grain materials in the microwave field. Holodil'naya tekhnika i tekhnologiya, 52 (1), 62–65. Available at: https://doaj.org/article/292517d0aad4490b8d20e039d86dcfb1
10. Rosa, D. P., Cantú-Lozano, D., Luna-Solano, G., Polachini, T. C., Telis-Romero, J. (2015). Mathematical modeling of orange seed drying kinetics. Ciência e Agrotecnologia, 39 (3), 291–300. doi: 10.1590/s1413-70542015000300011
11. Reis, R. C. dos, Devilla, I. A., Ascheri, D. P. R., Servulo, A. C. O., Souza, A. B. M. (2012). Kinetics of drying of basil leaves (Ocimum basilicum L.) in the infrared. Revista Brasileira de Engenharia Agrícola e Ambiental, 16 (12), 1346–1352. doi: 10.1590/s1415-43662012001200012
12. Grain moisture sensor in the flow. Available at: http://agrovektor.ru/art/1353-datchik-vlazhnosti-zerna-v-potoke.html
13. Han, F., Zuo, C., Wu, W., Li, J., Liu, Z. (2012). Model Predictive Control of the Grain Drying Process. Mathematical Problems in Engineering, 2012, 1–12. doi: 10.1155/2012/584376
14. Afonkina, V., Zakhakhatnov, V., Mayerov, V., Popov, V. (2016). On the question of process control combined grain drying. Mordovia University Bulletin, 26 (1), 032–039. doi: 10.15507/0236-2910.026.201601.032-039
15. Zhang, L., Cui, H., Li, H., Han, F., Zhang, Y., Wu, W. (2013). Parameters Online Detection and Model Predictive Control during the Grain Drying Process. Mathematical Problems in Engineering, 2013, 1–7. doi: 10.1155/2013/924698
16. Chen, C., Wu, C., Li, C. (2017). Design of Resistive Grain Moisture On-line Detector. MATEC Web of Conferences, 136, 02005. doi: 10.1051/matecconf/201713602005
17. SRT AIST 10.2-2010. Grain cleaning machines and aggregates, grain cleaning and drying complexes. Methods for assessing performance. Instead of SRT AIST 10.2-2004 and Enter. from 2011.04.15 (2011). Moscow, 48.
18. Klenin, N. I., Kiselev, S. N., Levshin, A. G. (2008). Agreecultural machines. Agreecultural equipment. Moscow: Colossus, 816.
19. Volkhonov, M. S., Gabalov, S. L., Jabbarov, I. A., Volkhonov, V. M. (2016). Substantiation of the method of control and management of the drying end of capillary – porous colloidal materials. Proceedings of the Kostroma State Agricultural Academy, 84, 56–65.
20. Zavarygin, V. M. (1991). Numerical methods. Moscow: Education, 250.
21. Bronshtein, I. N., Semendyaev, K. A. (1967). Handbook on Mathematics. Moscow: Nauka, 84.
22. Volkhonov, M. S., Polozov, S. A., Zyrin, I. S., Gabalov, S. L., Dzhumaliev, K. A. (2016). The basic principles of creating a system for automated control of the drying process in a mine air drier. Actual problems of science in the agro-industrial complex. Collection of articles of the 66th scientific-practical conference of the State Agricultural Academy, 85–90.

DOI: 10.15587/1729-4061.2018.133690

ELABORATION OF THE EQUIPMENT REPLACEMENT TERMS TAKING INTO ACCOUNT WEAR AND TEAR AND OBSOLESCENCE (p. 30-39)

Inna Lapkina
Odessa National Maritime University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0001-7468-8993

Mykola Malaksiano
Odessa National Maritime University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-4075-5112

The optimum terms of replacement of equipment subject to wear and tear and obsolescence with more advanced equipment with similar performance are investigated. To this end, the methodology of multi-criteria evaluation of equipment performance indicators when switching to a new type of equipment is proposed. The values of EAC (Equivalent Annual Cost), calculated for several equipment replacement cycles and for an infinite number of cycles are investigated. Estimates of the dispersion degree of EAC values depending on the service life of old and new equipment under conditions when the dynamics of operating costs is subject to random fluctuations are obtained. For this, covariance functions of random processes that describe the dynamics of the operating costs of old and new equipment were used. On the basis of covariance functions, estimates of the functions of standard deviations of EAC values are obtained. Using the obtained estimate of the degree of dispersion of equipment performance indicators, the multi-criteria optimization problem was investigated. This approach is of great practical interest, because for many enterprises, not only the average expected level of equipment performance indicators, but also the dispersion degree of the values of these indicators is of great importance. As a result of the research, the technique for planning the equipment replacement terms was developed. The proposed methodology allows justifying the terms of replacement of old equipment with new equipment, taking into account both the average expected EAC values and their level of fluctuations. The studies have shown that due to choosing the equipment renewal terms, it is possible to significantly reduce the degree of dispersion of equipment performance indicators, slightly sacrificing the average expected value.

Keywords: equipment replacement, equipment performance indicators optimization, equivalent annual cost, multi-criteria evaluation.

References

1. Adkins, R., Paxson, D. (2017). Replacement decisions with multiple stochastic values and depreciation. European Journal of Operational Research, 257 (1), 174–184. doi: 10.1016/j.ejor.2016.07.006
2. Lapkina, I., Malaksiano, M. (2018). Estimation of fluctuations in the performance indicators of equipment that operates under conditions of unstable loading. Eastern-European Journal of Enterprise Technologies, 1 (3 (91)), 22–29. doi: 10.15587/1729-4061.2018.123367
3. Nahorny, V. V. (2017). Automated control cutting based prediction of individual life of the cutting tool. Radio Electronics, Computer Science, Control, 3, 183–191. doi: 10.15588/1607-3274-2017-3-20
4. Zaloga, V. A., Nagorniy, V. M., Nagorniy, V. V. (2016). Kontrol' dinamicheskogo sostoyaniya metalloobrabatyvayushchey tekhnologicheskoy sistemy i prognozirovanie ee resursa. Sumy: Sumskiy gosudarstvenniy universitet, 242.
5. Stutzman, S., Weiland, B., Preckel, P., Wetzstein, M. (2017). Optimal replacement policies for an uncertain rejuvenated asset. International Journal of Production Economics, 185, 21–33. doi: 10.1016/j.ijpe.2016.12.018
6. Malaksiano, N. A. (2012). On the stability of economic indicators of complex port equipment usage. Actual Problems of Economics, 12, 226–233.
7. Mihaylov, V. V. (1973). Nadezhnost' elektrosnabzheniya promyshlennyh predpriyatiy. Moscow: Energiya, 168.
8. Zambujal-Oliveira, J., Duque, J. (2011). Operational asset replacement strategy: A real options approach. European Journal of Operational Research, 210 (2), 318–325. doi: 10.1016/j.ejor.2010.09.011
9. Liu, B., Wu, J., Xie, M. (2015). Cost analysis for multi-component system with failure interaction under renewing free-replacement warranty. European Journal of Operational Research, 243 (3), 874–882. doi: 10.1016/j.ejor.2015.01.030
10. Lapkina, I. O., Malaksiano, M. O., Malaksiano, M. O. (2016). Optimization of the structure of sea port equipment fleet under unbalanced load. Actual Problems of Economics, 9, 364–371.
11. Lapkina, I. O., Malaksiano, M. O. (2016). Modelling and optimization of perishable cargo delivery system through Odesa port. Actual Problems of Economics, 3, 353–365.
12. Hagspiel, V., Huisman, K. J. M., Nunes, C. (2015). Optimal technology adoption when the arrival rate of new technologies changes. European Journal of Operational Research, 243 (3), 897–911. doi: 10.1016/j.ejor.2014.12.024
13. Adkins, R., Paxson, D. (2013). Deterministic models for premature and postponed replacement. Omega, 41 (6), 1008–1019. doi: 10.1016/j.omega.2013.01.002
14. Chronopoulos, M., Siddiqui, A. (2014). When is it Better to Wait for a New Version? Optimal Replacement of an Emerging Technology under Uncertainty. Norwegian School of Economics, Department of Business and Management Science. Available at: https://brage.bibsys.no/xmlui/bitstream/handle/11250/217638/1/DiscussionPaper.pdf
15. Nguyen, T. P. K., Yeung, T. G., Castanier, B. (2013). Optimal maintenance and replacement decisions under technological change with consideration of spare parts inventories. International Journal of Production Economics, 143 (2), 472–477. doi: 10.1016/j.ijpe.2012.12.003
16. Jones, T. W., Smith, D. (1982). An historical perspective of net present value and equivalent annual cost. Accounting Historians Journal, 9 (1), 103–110. doi: 10.2308/0148-4184.9.1.103
17. Anderson, B. D. O., Bitmead, R. R., Johnson, C. R., Kokotovic, Jr., P. Y., Kosut, R. L., Mareels, I. M. V., Praly, L., Riedle, B. D. (1986). Stability of adaptive systems: passivity and averaging analysis. MIT Press, 326.
18. Lutsenko, I. (2016). Definition of efficiency indicator and study of its main function as an optimization criterion. Eastern-European Journal of Enterprise Technologies, 6 (2 (84)), 24–32. doi: 10.15587/1729-4061.2016.85453
19. Jardine, A., Tsang, A. (2013). Maintenance, Replacement, and Reliability. Theory and Applications. CRC Press, 364. doi: 10.1201/b14937
20. Volkov, I. K., Zuyev, S. M., Tsvetkova, G. M. (1999). Sluchaynye protsessy. Moscow: Izd-vo MGTU, 448.
21. Podinovskiy, V. V., Nogin, V. D. (1982). Pareto-optimal'nye resheniya mnogokriterial'nyh zadach. Moscow: Nauka, 256.

DOI: 10.15587/1729-4061.2018.133437

IMPLEMENTATION OF THE MARKET APPROACH TO THE PROCESSES OF MANAGEMENT OF THE ENERGY SECTOR OF UKRAINIAN ECONOMY UNDER CONDITIONS OF EUROPEAN INTEGRATION (p. 40-49)

Victoria Dergachova
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-0317-8675

Nadiia Pysar
Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0003-2656-7323

We developed the system of differential equations, which describes the level of supply of energy products (production and import) and demand for them (consumption). The equations take into consideration factors of prices for fuel-and-energy resources, exports, imports, as well as a mutual influence of the volumes of production of certain types of energy resources on others. We performed calculation of production, consumption and consumption of fuel-and-energy resources based on the constructed system. We obtained a normal system of linear differential equations of the first order, which describes the dependence between 7 resource components of the fuel-and-energy complex (gas, oil, black oil, coal, uranium, electricity, and thermal energy).

Efficient functioning of the energy market requires validity and transparency in the management of processes occurring in its system in the form of interaction of subsystems. The proposed holistic system of differential equations makes it possible to assess an energy supply potential of the energy market in accordance with the needs of consumers based on data on the level of reserves at the beginning of a year and production and consumption over the past year. Given such a model, it is possible to fore-

cast daily levels of consumption and supply of energy resources, taking into consideration seasonality of thermal energy production. Despite many equations and dependent variables, we found a numerical solution to the system. We used calculation formulas from the Euler method with step h=1 for this purpose. We obtained the solution in the form of tabulated values of functions of production or consumption of the corresponding energy resources. Based on the results of calculations, we built a graph of the corresponding dependences of parameters of the system of differential equations. We used the system of computer algebra wxMaxima for calculations.

Economic-mathematical modeling of energy market management processes is useful because it makes it possible to describe the resulting state of the energy market in Ukraine parametrically and opens up additional possibilities of forecasting taking into consideration stochastic phenomena of price and temperature.

Keywords: energy market, market model of management, liberalization, emergence, energy security, fuel-and-energy resources, market situation.

References

1. Wyłomańska, A., Borgosz-Koczwara, M. (2004). The equilibrium models in oligopoly electricity market. International Conference "The European Electricity Market EEM-04". Poland, 135–14.
2. Swindle, G. (2015). Valuation and Risk Management in Energy Markets. Published by Cambridge University Press, 487.
3. Brock, W. A., Malliaris, A. G. (1989). Differential Equations, Stability, and Chaos in Dynamic Economics. North-Holland, 389.
4. Dahl, C. (2002). Energy Demand and Supply Elasticities. In Encyclopedia of Life Support Systems (EOLSS). Oxford. Available at: http://www.eolss.net/Sample-Chapters/C08/E3-21-02-04.pdf
5. Dahl, C., Duggan, T. E. (1996). U.S. energy product supply elasticities: A survey and application to the U.S. oil market. Resource and Energy Economics, 18 (3), 243–263. doi: 10.1016/s0928-7655(96)00009-7
6. Alimba, J. O. (2010). Cost, demand and supply and price management in the power market. Being a Presentation at the Workshop on Electricity Economics to PHCN Staff at Abuja, 23.
7. 10 Factors Affecting the Energy Markets. Applied Energy Partners (2016). Available at: http://www.appenergy.com/2016/11/03/10-factors-affecting-the-energy-markets/
8. Buzoianu, M., Brockwell, A. E., Seppi, D. J. A. Dynamic Supply-Demand Model for Electricity Prices. Available at: http://www.stat.cmu.edu/tr/tr817/tr817.pdf
9. Rudkevich, A. On the Supply Function Equilibrium and its Applications in Electricity Markets. Available at: https://sites.hks.harvard.edu/hepg/Papers/Rudkevich.SFE.Feb.03.pdf
10. Audestad, J. A. Some Dynamic Market Models. Available at: https://arxiv.org/ftp/arxiv/papers/1511/1511.07203.pdf
11. Main Statistics Service of Ukraine. Energy balance of Ukraine (grocery) (2016). Available at: http://www.ukrstat.gov.ua/operativ/operativ2014/energ/en_bal_prod/arh_prod_2012.htm
12. Annual Report 2016. State Enterprise. National energy company Ukrenergo. Available at: https://ua.energy/wp-content/uploads/2018/02/Annual-report_2016.pdf
13. National Joint-Stock Company Naftogaz of Ukraine. Use of natural gas (2016). Available at: https://naftogaz-europe.com/
14. The method of solving the differential Euler equations. Available at: http://bourabai.kz/cm/euler.htm

DOI: 10.15587/1729-4061.2018.131939

COMPLEXIFICATION METHODS OF INTERVAL FORECAST ESTIMATES IN THE PROBLEMS ON SHORTTERM PREDICTION (p. 50-58)

Yuri Romanenkov
N. E. Zhukovsky National Aerospace University «Kharkiv Aviation Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-3526-7237

Mariia Danova
N. E. Zhukovsky National Aerospace University «Kharkiv Aviation Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-8116-8598

Valentyna Kashcheyeva
N. E. Zhukovsky National Aerospace University «Kharkiv Aviation Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-6383-0824

Oleg Bugaienko
N. E. Zhukovsky National Aerospace University «Kharkiv Aviation Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-1511-9990

Maksym Volk
Kharkiv National University of Radio Electronics, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-4229-9904

Maryna Karminska-Bielobrova
National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-7978-866X

Olena Lobach
National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-7494-9997

We solved the problem of improvement of methodological base for a decision support system in the process of short-term prediction of indicators of organizational-technical systems by developing new, and adapting existing, methods of complexification that are capable of taking into consideration the interval uncertainty of expert forecast estimates. The relevance of this problem stems from the need to take into consideration the uncertainty of primary information, predetermined by the manifestation of NON-factors. Analysis of the prerequisites and characteristics of formalization of uncertainty of primary data in the interval form was performed, the merits of interval analysis for solving the problems of complexification of interval forecast estimates were identified. Brief information about the basic mathematical apparatus was given: interval arithmetic and interval analysis. The methods of complexification of forecast estimates were improved through the synthesis of interval extensions, obtained in accordance with the paradigm of an interval analysis. We found in the course of the study that the introduction of the analytical preference function made it possible to synthesize the

model of complexification in a general way, by aggregating the classes of hybrid and selective models in a single form for the generation of consolidated predictions based on interval forecast estimates. This allows obtaining complexification predictions based on the interval forecast estimates, thereby ensuring accuracy of the consolidated short-term prediction.

Critical analysis of the proposed methods was performed and recommendations on their practical application were developed. Recommendations for parametric setting of the analytic function of preferences were stated. Using the example, the adaptive properties of the interval model of complexification were shown.

Keywords: short-term prediction, complexification of forecast estimates, decision support, interval analysis.

References

1. Oklander, M. A., Yashkina, O. I. (2013). Kontseptsiya formuvannia systemy marketynhovykh doslidzhen innovatsiy mashynobudivnoho pidpryiemstva. Ekonomist, 11 (325), 52–56.
2. Romanenkov, Y., Vartanian, V. (2016). Formation of prognostic software support for strategic decision-making in an organization. Eastern-European Journal of Enterprise Technologies, 2 (9 (80)), 25–34. doi: 10.15587/1729-4061.2016.66306
3. Yashkina, O. (2013). Natsionalna systema stratehichnykh marketynhovykh doslidzhen naukovo-tekhnolohichnoho rozvytku. Ekonomist, 1, 26–29.
4. Malitskyi, B. A., Popovych, O. S., Soloviov, V. P. (2004). Metodychni rekomendatsiyi shchodo provedennia prohnoznoanalitychnoho doslidzhennia v ramkakh Derzhavnoi prohramy prohnozuvannia naukovo-tekhnolohichnoho ta innovatsiynoho rozvytku Ukrainy. Kyiv: Feniks, 52.
5. Shostak, I. V., Danova, M. A., Romanenkov, Yu. A. (2015). Informacionnaya tekhnologiya podderzhki prinyatiya ekspertnyh resheniy v nacional'nyh Forsayt-issledovaniyah. Komunalne hospodarstvo mist, 123, 58–67.
6. Cuhls, K. (2008). Foresight in Germany. The Handbook of Technology Foresight. Cheltenham: Edward Elgar, 131–153.
7. Johnston, R., Sripaipan, C. (2008). Foresight in Industrialising Asia. The Handbook of Technology Foresight. Cheltenham: Edward Elgar, 333–356.
8. Bugas, D. (2016). Modelling the expert's preferences in decision-making under complete uncertainty. Eastern-European Journal of Enterprise Technologies, 5 (4), 12–17. doi: 10.15587/1729-4061.2016.81306
9. Bidyuk, P. I., Gasanov, A. S., Vavilov, S. E. (2013). Analiz kachestva ocenok prognozov s ispol'zovaniem metoda kompleksirovaniya. Systemni doslidzhennia ta informatsiyni tekhnolohiyi, 4, 7–16.
10. Buravcev, A. V. (2017). Seriy upravlencheskiy analiz. Perspektivy Nauki i Obrazovaniya, 5 (29), 74–79.
11. Kryuchkovskiy, V. V., Usov, A. V. (2009). Teoreticheskiy analiz interval'noy neopredelennosti poleznosti resheniy. Trudy Odesskogo politekhnicheskogo universiteta, 1-2, 180–186.
12. Bates, J. M., Granger, C. W. J. (1969). The Combination of Forecasts. Journal of the Operational Research Society, 20 (4), 451–468. doi: 10.1057/jors.1969.103
13. Newbold, P., Granger, C. W. J. (1974). Experience with Forecasting Univariate Time Series and the Combination of Forecasts. Journal of the Royal Statistical Society. Series A (General), 137 (2), 131. doi: 10.2307/2344546
14. Sineglazov, V. M., Chumachenko, E. I., Gorbatyuk, V. S. (2012). Metod resheniya zadachi prognozirovaniya na osnove kompleksirovaniya ocenok. Induktyvne modeliuvannia skladnykh system, 4, 214–223.
15. Vasil'ev, A. A. (2015). Ob'edinenie prognozov ekonomicheskih pokazateley na osnove bives-ocenki s vesovoy funkciey H'yubera. Aktual'nye problemy gumanitarnyh i estestvennyh nauk, 10-4, 44–47.
16. Molev, M. D., Zanina, I. A., Stuzhenko, N. I. (2013). Sintez prognoznoy informacii v praktike ocenki ekologo-ekonomicheskogo razvitiya regiona. Inzhenerniy vestnik Dona, 4, 59.
17. Romanenkov, Yu. A., Vartanyan, V. M., Revenko, D. S. (2014). Kompleksirovanie prognoznyh ocenok v sisteme monitoringa pokazateley sostoyaniya biznes-processa. Systemy upravlinnia, navihatsiyi ta zviazku, 2, 94–101.
18. Sternin, M. Yu., Shepelev, G. I. (2009). Sravnenie poliinterval'nyh ocenok v metode OIO. Intelligent Support of Decision Making. International book series «Information science & computing», 10, 83–88.
19. Shepelev, G. I., Sternin, M. Yu. (2014). Ob adekvatnosti tochechnyh kriteriev zadacham ocenki i sravneniya interval'nyh al'ternativ. Iskusstvenniy intellekt i prinyatie resheniy, 2, 78–88.
20. Levin, V. I. (2004). Uporyadochenie intervalov i zadachi optimizacii s interval'nymi parametrami. Kibernetika i sistem. analiz, 3, 14–24.
21. Batyrshin, I. Z. et. al.; Yarushkina, N. G. (Ed.) (2007). Nechetkie gibridnye sistemy: teoriya i praktika. Moscow: Fizmatlit, 207.
22. Kamolov, E. R. (2017). Osnovnye vidy i tipy neopredelennosti informacii, harakternye dlya slozhnyh biotekhnologicheskih system. Molodoy ucheniy, 27, 36–39.
23. Shishin, V. V. (2012). Metody analiza eksperimental'nyh dannyh s razlichnymi vidami neopredelennosti. Sovremennye problemy nauki i obrazovaniya, 6, 11.
24. Revenko, D. S., Vartanyan, V. M. (2009). Razrabotka metoda formirovaniya interval'nyh dannyh na osnove ekspertnoy informacii. Ekonomika ta upravlinnia pidpryiemstvamy mashynobudivnoi haluzi, 1, 24–30.
25. Bardachev, Yu. N., Kryuchkovskiy, V. V., Malomuzh, T. V. (2010). Metodologicheskaya predpochtitel'nost' interval'nyh ekspertnyh ocenok pri prinyatii resheniy v usloviyah neopredelennosti. Visnyk Kharkivskoho natsionalnoho universytetu imeni V. N. Karazina. Seriya: Matematychne modeliuvannia. Informatsiyni tekhnolohiyi. Avtomatyzovani systemy upravlinnia, 890, 18–28.
26. Podruzhko, A. A., Podruzhko, A. S., Kiricev, P. N. (2009). Interval'nye metody resheniya zadach kalibrovki i klassifikacii. Trudy Instituta sistemnogo analiza Rossiyskoy Akademii nauk. Dinamika neodnorodnyh system, 44, 173–186.
27. Voshchinin, A. P. (2002). Interval'niy analiz dannyh: razvitie i perspektivy. Zavodskaya Laboratoriya, 68 (1), 118–126.
28. Kochkarov, R. A. (2015). Interval'nye zadachi na predfraktal'nyh grafah. Novye informacionnye tekhnologii v avtomatizirovannyh sistemah, 18, 255–264.

29. Orlov, A. I. (2013). Osnovnye idei statistiki interval'nyh dannyh. Nauchnyy zhurnal KubGAU, 94, 55–70.
30. Levin, V. I. (2002). Sravnenie intervalov i optimizaciya v usloviyah neopredelennosti. Vestnik Tambovskogo universiteta. Seriya: Estestvennye i tekhnicheskie nauki, 3, 383–389.
31. Vartanyan, V. M., Shah, L. G., Romanenkov, Yu. A. (2003). Postroenie i analiz interval'nyh nestatisticheskih modeley. Tekhnologicheskie sistemy, 3 (19), 19–24.
32. Vartanyan, V. M., Romanenkov, Yu. A., Kashcheeva, V. Yu., Revenko, D. S. (2009). Parametricheskiy sintez modeli eksponencial'nogo sglazhivaniya dlya statisticheskih ryadov interval'nyh dannyh. Otkrytye informacionnye i komp'yuternye integrirovannye tekhnologii, 44, 232–240.
33. Lai, Q., Liu, J., Luo, Y., Ma, M. (2017). A Hybrid Short-Term Forecasting Model of Passenger Flow on High-Speed Rail considering the Impact of Train Service Frequency. Mathematical Problems in Engineering, 2017, 1–9. doi: 10.1155/2017/1828102

DOI: 10.15587/1729-4061.2018.132683

DEVELOPMENT OF A MODEL FOR THE INTEGRATED MANAGEMENT OF THE INTERNATIONAL DELIVERY CHAINS FORMATION (p. 59-72)

Nataliya Khalipova
University of Customs and Finance, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0001-5605-6781

Arkadii Bosov
Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0002-5348-2205

Iryna Progonyuk
University of Customs and Finance, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0002-2781-2864

We propose a model for the formation of international logistics chains based on an integrated multicriterial analysis of potential cargo transportation routes and delivery cost. The application of the systemic approach when planning a delivery helps to ensure rational allocation and efficient servicing of traffic flows among the objects along the transportation-logistic network.

At the first stage of modeling, the analysis of information about the objects of the transport and logistic system is carried out. We determine the region of efficient use of different modes of transport and construct a set of alternative chains of good delivery. Based on the analysis of the impact factors, the criteria are determined and the constraints are accepted to a given problem for a series of techno-economic, logistical, technological, environmental and other indicators. At the second stage, the multicriterial problem of synthesis (engineering) of the transport and logistics system of delivery is solved.

We built an algorithm for the substantiation of effective international multi-modal transport and technological schemes of cargo delivery. The proposed algorithm provides a comprehensive assessment of the cost depending on delivery conditions in accordance with the Incoterms rules and the customs regime. To substantiate the route, the region of effective solutions for a DM is determined, based on solving a problem on the vector optimization for multiple criteria.

Formation of effective schemes of cargo delivery from France to Ukraine along the route from Haut-Mauco to the warehouse "Agro-Soyuz-Terminal" in the city of Dnipro was explored. Based on modeling applying the package of symbolic computations in the programming environment Maple-7, we obtained a full set of compromise solutions to the vector optimization problem for the criteria of cost, delivery time, and ecological impact. We present a comprehensive assessment of the cost of goods delivery in containers using mixed transportation under the Incoterms EXW, CPT delivery conditions (delivery to Dnipro), FOB and CIF, and the customs regime of import and import (warehouse).

The proposed model could be applied by transportation, logistic, customs brokering companies when substantiating alternative routes of goods delivery based on a multicriterial analysis of information.

Keywords: international delivery chains, multi-modal mixed cargo transportation, multicriterial analysis, vector optimization.

References

1. Minina, O. V. (2010). Suchasnyi stan tranzytnoi spromozhnosti Ukrainy v konteksti yevroaziatskoi intehratsiyi. Visnyk Chernihivskoho derzhavnoho universytetu, 44, 53–65.
2. Korniyko, Ya. R., Filonenko, O. O. (2017). Formuvannia mekhanizmu intehrovanoho lohistychnoho upravlinnia konteinernymy vantazhopotokamy. Naukovyi visnyk Uzhhorodskoho natsionalnoho universytetu. Seriya: Mizhnarodni ekonomichni vidnosyny ta svitove hospodarstvo, 11, 69–72.
3. Valiavska, N. O. (2016). Orhanizatsiyno-ekonomichnyi mekhanizm rozvytku richkovykh portiv Ukrainy. Investytsiyi: praktyka ta dosvid: mizhnarodnyi naukovo-praktychnyi zhurnal, 4, 58–61.
4. Pidlisnyi, P. I., Patkevych, N. O., Tsvietov, Yu. V. (2016). Rol konteineryzatsiyi zmishanykh vantazhnykh perevezen u rozvytku svitovoi torhivli. Ekonomichnyi forum, 3, 67–81. Available at: http://nbuv.gov.ua/UJRN/ecfor_2016_3_11
5. Karttunen, K., Lättilä, L., Korpinen, O.-J., Ranta, T. (2013). Cost-efficiency of intermodal container supply chain for forest chips. Silva Fennica, 47 (4). doi: 10.14214/sf.1047
6. Kengpol, A., Tuammee, S., Tuominen, M. (2014). The development of a framework for route selection in multimodal transportation. The International Journal of Logistics Management, 25 (3), 581–610. doi: 10.1108/ijlm-05-2013-0064
7. Miler, R. K. (2015). Electronic Container Tracking System as a Cost-Effective Tool in Intermodal and Maritime Transport Management. Economic Alternatives, 1, 40–52.
8. Karmelić, J., Dundović, Č., Kolanović, I. (2012). Empty Container Logistics. PROMET – Traffic&Transportation, 24 (3). doi: 10.7307/ptt.v24i3.315
9. Kos, S., Vukić, L., Brčić, D. (2017). Comparison of External Costs in Multimodal Container Transport Chain. PROMET – Traffic&Transportation, 29 (2), 243. doi: 10.7307/ptt.v29i2.2183
10. Panahi, R., Ghasemi Koohi Kheili, A., Golpira, A. (2017). Future of Container Shipping in Iranian Ports: Traffic and Connectivity Index Forecast. Journal of Advanced Transportation, 2017, 1–13. doi: 10.1155/2017/5847372

11. An, F., Hu, H., Xie, C. (2015). Service network design in inland waterway liner transportation with empty container repositioning. European Transport Research Review, 7 (2). doi: 10.1007/s12544-015-0157-5
12. Hadj Khalifa, I., El Kamel, A., Yim, P. (2011). Transportation Process of Containers BPMN-Modeling and Transformation into ACTIF Model. Romanian Journal Of Information Science And Technology, 14 (1), 67–80.
13. Liu, T., Zheng, G. (2017). Study Logistics Architecture for Grain Container Multimodal Transport Based on Multi-Agent. Proceedings of The 7th International Conference on Computer Engineering and Networks – PoS(CENet2017). doi: 10.22323/1.299.0049
14. Hao, C., Yue, Y. (2016). Optimization on Combination of Transport Routes and Modes on Dynamic Programming for a Container Multimodal Transport System. Procedia Engineering, 137, 382–390. doi: 10.1016/j.proeng.2016.01.272
15. Liu, D., Yang, H. (2015). Joint slot allocation and dynamic pricing of container sea–rail multimodal transportation. Journal of Traffic and Transportation Engineering (English Edition), 2 (3), 198–208. doi: 10.1016/j.jtte.2015.03.008
16. Jiang, B., Li, J., Mao, X. (2012). Container Ports Multimodal Transport in China from the View of Low Carbon. The Asian Journal of Shipping and Logistics, 28 (3), 321–343. doi: 10.1016/j.ajsl.2013.01.003
17. Shramenko, N. Yu. (2015). Formuvannia alternatyvnykh variantiv transportno-ekspedytorskoho obsluhovuvannia vantazhovlasnykiv pid chas intermodalnykh perevezen. Avtomobil'niy transport, 37, 70–77. Available at: http://nbuv.gov.ua/UJRN/at_2015_37_12
18. Vyshnevskyi, D. O., Vyshnevska, O. D. (2017). Kryteriyi vidboru alternatyvnykh variantiv dostavky zovnishnotorhivelnykh vantazhiv. Visnyk Skhidnoukrainskoho natsionalnoho universytetu imeni Volodymyra Dalia, 4, 262–264. Available at: http://nbuv.gov.ua/UJRN/VSUNU_2017_4_52
19. Naumov, V. S., Potaman, N. V., Viter, N. S. (2013). Forming a set of alternate variants of transport and technological container cargo delivery systems. Eastern-European Journal of Enterprise Technologies, 4 (4 (64)), 58–60. Available at: http://journals.uran.ua/eejet/article/view/16342/13853
20. Hao, C., Yue, Y. (2016). Optimization on Combination of Transport Routes and Modes on Dynamic Programming for a Container Multimodal Transport System. Procedia Engineering, 137, 382–390. doi: 10.1016/j.proeng.2016.01.272
21. Brands, MSc T., van Eck, MSc G. (2010). Multimodal Network Design And Assessment. Proposal for a dynamic multi-objective approach. 11th TRAIL Congress.
22. Kovalenko, I., Mandra, A., Bordun, S. (2016). Informacionnaya tekhnologiya vybora transportnyh sredstv dlya organizacii mul'timodal'nyh perevozok gruzov. Naukovyi zhurnal: MNU imeni V. O. Sukhomlynskoho. Heometrychne modeliuvannia ta informatsiyni tekhnolohiyi, 2, 39–44.
23. Baranovskaya, T. P., Pavlov, D. A. (2016). Modelirovanie krupnomasshtabnyh transportnyh setey s primeneniem metodov mnogokriterial'noy optimizacii i uchetom strukturnoy dinamiki. Nauchniy zhurnal KubGAU, 120 (06). Available at: http://ej.kubagro.ru/2016/06/pdf/111.pdf
24. Zadorov, V. B., Fedusenko, E. V., Fedusenko, A. O. (2010). Zastosuvannia metodiv bahatokryterialnoi optymizatsiyi do planuvannia vantazhnykh perevezen. Upravlinnia rozvytkom skladnykh system, 2, 27–30.
25. Kreutzberger, E. D. (2008). Distance and time in intermodal goods transport networks in Europe: A generic approach. Transportation Research Part A: Policy and Practice, 42 (7), 973–993. doi: 10.1016/j.tra.2008.01.012
26. Andersen, J., Crainic, T. G., Christiansen, M. (2009). Service network design with management and coordination of multiple fleets. European Journal of Operational Research, 193 (2), 377–389. doi: 10.1016/j.ejor.2007.10.057
27. Feng, F., Zhang, Q. (2015). Multimodal Transport System Coevolution Model Based on Synergetic Theory. Discrete Dynamics in Nature and Society, 2015, 1–10. doi: 10.1155/2015/108926
28. Lei, K., Zhu, X., Hou, J., Huang, W. (2014). Decision of Multimodal Transportation Scheme Based on Swarm Intelligence. Mathematical Problems in Engineering, 2014, 1–10. doi: 10.1155/2014/932832
29. Levkovec, P. R., Tovkun, D. L. (2001). Tekhnologicheskie i ekonomicheskie aspekty logisticheskogo upravleniya mul'timodal'nymi perevozkami. Systemni metody keruvannia, tekhnolohiya ta orhanizatsiia vyrobnytstva y ekspluatatsiyi avtomobiliv, 12, 262–269.
30. Karpenko, O. O. (2007). Lohistyka v systemi zmishanykh perevezen. Problemy pidvyshchennia efektyvnosti infrastruktury, 13, 65–72.
31. Beleckiy, Yu. V., Miroshnikova, M. V., Sergienko, A. V. (2015). Analiz sistem vzaimodeystviya razlichnyh vidov transporta na osnove formirovaniya transportno-logisticheskih cepey pri mul'timodal'nyh perevozkah. Visnyk Skhidnoukrainskoho natsionalnoho universytetu im. Volodymyra Dalia, 1, 210–212.
32. Khalipova, N. V. (2013). Modeliuvannia lohistychnykh system mizhnarodnykh perevezen. Vestnik Vostochnoukrainskogo nacional'nogo universiteta imeni Vladimira Dalya, 5 (194), 73–80.
33. Huzhevska, L. A., Basanets, T. Yu., Veronska, L. T. (2010). Vybir mytnoho rezhymu yak odna iz zadach mytnoi lohistyky. Visnyk Natsionalnoho transportnoho universytetu, 21, 111–114.
34. Yablonskys, A. (2011). Mizhnarodna lohistyka y mytna diyalnist. Tezy dopov. mizhn. nauk.-prakt. konf. "Perspektyvy rozvytku informatsiynykh ta transportno-mytnykh tekhnolohiy u mytniy spravi, zovnishnoekonomichniy diyalnosti ta upravlinni orhanizatsiyamy". Dnipropetrovsk.
35. Servis dlia rozrakhunku vidstanei mizh mistamy. Available at: https://www.google.com.ua/maps/
36. Taryfna stavka na vantazhni perevezennia. Available at: http://della.ua/price/66/
37. Platnye dorogi v Evrope. Available at: https://autotraveler.ru/spravka/toll-road-in-europe.html#.Wiu-mEpl_IU
38. Ekologicheskie zony v Germanii. Available at: http://traveleu.ru/roads/europeRoads.htm
39. Zaborona rukhu vantazhnoho transportu u Yevropi. Available at: http://www.lkw-walter.ua/uk/pereviznyk/korisna-informaciya/svjatkovi-dni-iz-zaboronoju-transportuvannja
40. Koncepciya organizacii kontreylernyh perevozok na «prostranstve 1520» (2011). Moscow: OAO «RZHD», 149.

41. Dohovir pro Mizhnarodnyi zaliznychnyi tranzytnyi taryf ta MTT vid 01.03.2012 roku. Verkhovna Rada Ukrainy. Available at: http://zakon2.rada.gov.ua/laws/show/998_229/page12
42. Mezhdunarodnyy zheleznodorozhnyy tranzitniy tarif MTT: Prilozhenie k Dogovoru o Mezhdunarodnom zheleznodorozhnom tranzitnom tarife. Varshava: Oficial'noe izdanie Komiteta OSZHD. Available at: http://portal.kazlogistics.kz/upload/iblock/70b/70bcce7ff5f28eaa0850e0b6cd65edd4.pdf
43. Nakaz ministerstva infrastruktury Ukrainy vid 14.11.2016 r. No. 399 «Pro taryfnu polityku zaliznychnykh dorih derzhavuchasnyts spivdruzhnosti nezalezhnykh derzhav na perevezennia vantazhiv v mizhnarodnomu spoluchenni na 2017 frakhtovyi rik». Verkhovna Rada Ukrainy. Available at: http://zakon2.rada.gov.ua/laws/show/z1559-16
44. Onlain servis dlia rozrakhunku morskoho frakhtu. Available at: http://www.freight-charges.com/
45. Subsidiary Company Container Terminal Odessa member of the HHLA Group. Information For Customers. Tarrifs: Actual Tariffs In Word Format. Available at: http://cto.od.ua/en/dep/law/law_1.html
46. Prays-list na poslugi TOV «Agro-Soyuz-Terminal». URL: http://asterminal.dp.ua/services/skladskie-uslugi/
47. Bosov, A. A., Ilman, V. M., Khalipova, N. V. (2015). Multiple objects. Science and Transport Progress. Bulletin of Dnipropetrovsk National University of Railway Transport, 3 (57), 145–161. doi: 10.15802/stp2015/46075
48. Halipova, N. V. (2014). Ocenka effektivnosti funkcionirovaniya mezhdunarodnyh logisticheskih system. Tekhnicheskie nauki – ot teorii k praktike: sb. st. po materialam XXXVI mezhdunar. nauch.-prakt. konf. Novosibirsk: Izd. SibAK, 7 (32), 99–115.
49. Halipova, N. V. (2015). Obosnovanie primeneniya diskretnogo principa maksimuma v metode faz pri proektirovanii logisticheskih sistem dostavki gruzov. Universum: Tekhnicheskie nauki, 1 (14). Available at: http://7universum.com/ru/tech/archive/item/1891
50. Khalipova, N. V. (2015). International logistics systems design and effectiveness evaluation. Science and Transport Progress. Bulletin of Dnipropetrovsk National University of Railway Transport, 4 (58), 142–152. doi: 10.15802/stp2015/49222