Artem A. Madykh
candidate of economic sciences
E-mail: artem.madykh@gmail.com

Oleksiy O. Okhten
candidate of economic sciences
E-mail: aokhten@gmail.com

Alla F. Dasiv
candidate of economic sciences
Institute of the Economy of Industry of the NAS of Ukraine
03057, Ukraine, Kiev, Zhelyabova str., 2
E-mail: alladasiv@gmail.com

Analysis of the world experience of economic and mathematical modeling of smart enterprises
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Abstract:
The paper shows the inevitability of technological mode shift driven by the Industry 4.0, which implies the ubiquitous implementation of information technology, total automation of various processes and creation of cyber-physical systems with artificial intelligence. This requires a complete restructuring of manufacturing systems and production relations, especially in the economies of those countries that want to take a decent place in the new international division of labour of the digital future.

An analysis of the world experience of such changes connected with smart industrialization, digital transformations of the economy, the emergence of the industrial Internet of Things and big data processing made it possible to draw the conclusion that it is necessary to apply economic and mathematical methods to justify the expediency of such transformations: economic validity, as well as physical viability of newly created systems. The use of the apparatus of economic and mathematical modeling allows studying properties of the smart system that is being designed, evaluating its effectiveness and risks, anticipating the emergence of problems and errors ♦ without the risk of incurring significant losses which is inevitable when making direct changes in the object of research.

Therefore, the purpose of this paper is to study the world experience in the economic and mathematical modeling of smart enterprises and to substantiate its use in the conditions of Ukraine.

The review of publications, reflecting the aspects of economic and mathematical modeling in these areas, allowed to conclude that the methodical and methodological apparatus for modeling these processes is unsystematic and inefficient, as well as to formulate recommendations on the economic and mathematical modeling of smart enterprises in Ukraine. In order to take into account the specific features of Ukraine's technological and institutional development, a number of economic and mathematical modeling tools based on the use of production functions, models of inter-branch balance, network

optimization models and simulation models based on stochastic dependencies were offered to support the creation of smart enterprises.

Keywords: Industry 4.0, digital technologies, smart enterprises, big data, economic and mathematical modeling.
JEL code: ?00; ?60; ?67; ?69; ?12; ?14.

References

1. Analysis of World Experience in the Development of Industry and Approaches to the Digital Transformation of the Industry of the Member States of the Eurasian Economic Union: Informational and Analytical Report (2017). Moscow: Eurasian Economic Commission [in Russian].
2. Byelyakov, K.I. (2008). Informati-zation in Ukraine: Problems of organiza-tional, Legal and Scientific Support: mono-graph. ?yiv: KVIC [in Ukrainian].
3. Vasilenko, V. (2013). Technological Modes in the Context of the Aspiration of Economic Systems to the Ideal. Sotsial'no-ekonomichni problemy i derzhava, 1, Vol. 8, pp. 65-72 [in Russian].
4. Voronin, A.V. (2013). Modeling of Technical Systems. Tomsk: Tomsk Poly-technic University [in Russian].
5. Glazev, S.Yu. (2012). The Modern Theory of Long Waves in the Development of the Economy. Ekonomicheskaya nauka sovremennoy Rossii, 2 (57), pp. 8-27 [in Russian].
6. Gromova, T. Will the world survive the fourth industrial revolution? Delovaya stolitsa. Retrieved from <http://fastsalttimes.com/sections/obzor/522.html> [Accessed 07 Oct. 2017] [in Russian].
7. "Digital Dividends" World Devel-opment Report (2016). Washington: Interna-tional Bank for Reconstruction and Devel-opment / World Bank [in Russian].
8. Dyuzhev, D.V. (2008). The Specifics of Information Society Formation in Ukraine: History and Modernity. Nauka. Relihiya. Suspil'stvo, 2, pp. 130-135 [in Russian].
9. The Law of Ukraine "On the Basic Principles of the Development of the Infor-mation Society in Ukraine for 2007-2015" (2007). Uryadovyy kur"yer, 28 [in Ukrainian].
10. Information Technologies in Ukraine: The Colossus on Clay Feet. Retrieved from <https://dou.ua/lenta/articles/it-in-ukraine/> [Accessed 07 Oct. 2017] [in Russian].
11. Information Technologies as the Stimulus for the Development of Ukrainian Society. Retrieved from <http://data.ngorg.od.ua/ru/informacionnye-tehnologii-kak-stimul-razvitiya-ukrainskogo-obshchestva> [Accessed 11 Sept. 2017] [in Russian].
12. Kaplan, A.V., Kaplan, V.E., Mas-chenko, M.V., & Ovechkina, E.V. (2007). The Solution of Optimization Tasks in the Economy. Moscow: Fenix [in Russian].
13. Kupriyanovskiy, V.P., Namiot, D.E., & Sinyagov, S.A. (2016). Cyber-Physical Systems as the Basis of the Digital Economy. International Journal of Open Information Technologies, 2, Vol. 4, pp. 18-25 [in Russian].
14. Kupriyanovskiy, V.P., Sinyagov, S.A., Namiot, D.E., Utkin, N.A., Nikolaev, D.E., & Dobryinin, A.P. (2017). Transformation of Industry in the Digital Economy ♦ Design and Manufacturing. International Journal of Open Information Technologies, 1, Vol. 5, pp. 50-70 [in Russian].
15. Paklin, N.B., & Oreshkov, V.I. (2009). Business Intelligence: from Data to Knowledge. St. Petersburg: Peter [in Russian].
16. The Portrait of a Ukrainian IT professional. Retrieved from <https://dou.ua/lenta/articles/portret-ukrainskogo-it-specialista/> [Accessed 19 Sept. 2017] [in Russian].
17. "Industry 4.0": Creation of a Digital Enterprise. The Main Results of the Research in the Metallurgical Industry/ PwC. Retrieved from https://www.pwc.ru/ru/mining-and-metals/publications/assets/industry-4-metals-key-findings_rus.pdf [Accessed 28 Sept. 2017] [in Russian]
18. Distributed data processing using Hadoop. IBM, 2017 [in

Written by ?????????? ?.

Wednesday, 06 December 2017 00:28 - Last Updated Thursday, 07 December 2017 13:53

Russian].
 19. Romanchuk, Ya. Third industrial revolution: essence, influence, consequences. Retrieved from <http://liberty-belarus.info/o-kapitalizme/kapitalizm-dlya-lyuboznatelnykh/item/848-tretya-promyshlennaya-revolutsiya-sut-vliyanie-posledstviya#l2> [Accessed 25 Aug. 2017] [in Russian].
 20. State, Problems and Prospects of the Development of the Information Society in the CIS. (2012). Commonwealth of Independent States. Executive committee. Moscow [in Russian].
 21. Trofimova, E. (2016). Cyber Vulnerability of the Smart Manufacturing. *Control Engineering Rossiya*, 1 (61), pp. 34-36 [in Russian].
 22. Chekletsov, V. (2015). The Fourth Revolution: Internet of Things. *Ekspert*, January, pp. 42-44. Retrieved from <http://www.ncca.ru/file?Files&141> [Accessed 08 Sept. 2017]. [in Russian].
 23. Sheer, A.-V. What's Behind the Term "Industry 4.0". Retrieved from <http://www.i-love-bpm.ru/s%D1%81heer/chto-skryvaetsya-za-terminom-industriya-40> [Accessed 08 Sept. 2017]. [in Russian].
 24. Atzori, L., Lera, A., & Morabito, G. (2010). The internet of things: a survey. *Computer Networks*. ????? ??????: https://www.researchgate.net/profile/Luigi_Atzori2/publication/222571757_The_Internet_of_Things_A_Survey/links/546b36df0cf2f5eb180914e5/The-Internet-of-Things-A-Survey.pdf [Accessed 28 Sept. 2017].
 25. Auschitzky, E., Hammer, M., & Rajagopaul, A. How big data can improve manufacturing. *McKinsey*. ????? ??????: <http://www.mckinsey.com/business-functions/operations/our-insights/how-big-data-can-improve-manufacturing> [Accessed 28 Sept. 2017].
 26. Brynjolfsson, E., & McElheran, K. Data in Action: Data-Driven Decision Making in U.S. Manufacturing. ????? ??????: http://www.economics.cornell.edu/sites/default/files/files/events/Brynjolfsson_McElheran_AEA_2016.pdf [Accessed 25 Aug. 2017].
 27. Dymola for physical modelling and simulation using Modelica. Claytex. ????? ??????: <http://www.claytex.com/products/dymola/> [Accessed 28 Sept. 2017].
 28. Fishwick, P. (2007). *Handbook of Dynamic System Modeling* (Chapman & Hall/CRC Computer and Information Science Series). New York: Chapman and Hall/CRC.
 29. Geisberger, E., & Broy, M. (2012). *Agenda CPS: Integrierte Forschungsagenda Cyber-Physical Systems (acatech STUDIE)* (German Edition). New York: Springer-Verlag, 297 p.
 30. Gröer, C., Niedermann, F., & Mitschang, B. (2012, July) Data Mining-driven Manufacturing Process Optimization. *Proceedings of the World Congress on Engineering* (Vol. III, pp. 1475-1481). London: WCE.
 31. Hermann, M., Pentek, T., & Otto, B. (2016). Design Principles for Industrie 4.0 Scenarios. 49th Hawaii International Conference on System Sciences (HICSS), pp. 3928-3937.
 32. Hu, H., Wen, Y., Chua, T.-S., & Li, X. (2014). Toward Scalable Systems for Big Data Analytics: a Technology Tutorial. *IEEE Access*, 2, pp. 652-687.
 33. Industrie 4.0 ♦ What is it? Germany Trade & Invest. ????? ??????: <https://industrie4.0.gtai.de/INDUSTRIE40/Navigation/EN/Topics/Industrie-40/what-is-it.html> [Accessed 08 Sept. 2017].
 34. Information Resources Management Association. *The Internet of Things: Breakthroughs in Research and Practice* (2017). Information Resources Management Association. Hershey: IGI Global.
 35. Innovationen für die Produktion von morgen. ????? ??????: https://www.bmbf.de/pub/Industrie_4.0.pdf [Accessed 08 Sept. 2017].
 36. Jeschke, S., Brecher, C., Song, H., & Rawat, D. (2017). *Industrial Internet of Things. Cybermanufacturing Systems*. Herausgeber: Springer International Publishing Switzerland.
 37. Kim, K., Jung, J.-K., & Choi, J.-Y. (2016). Impact of the Smart City Industry on the Korean National Economy: Input-Output Analysis. *Sustainability*, 8 (7), pp. 649-678.
 38. Lasi, H., Kemper, H.-G., Fettke, P., Feld, T., & Hoffmann, M. (2014). *Industry 4.0. Business & Information Systems*

Written by ?????????? ?.

Wednesday, 06 December 2017 00:28 - Last Updated Thursday, 07 December 2017 13:53

Engi-neering, 4 (6), pp. 239-242.
 39. Lee, J., Lapira, E., Bagheri, B., & Kao, H. (2013). Recent advances and trends in predictive manufacturing systems in big data environment. Manufacturing Letters, 1. pp. 38-41.
 40. Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Hung Byers, A. (2011). Big data: The next frontier for innovation, competition, and productivity. New York: McKinsey Global Institute.
 41.♦Nedelcu, B. (2013). About Big Data and its Challenges and Benefits in Manufacturing. Database Systems Journal, 4, Issue 3, pp. 10-19.
 42.♦Networked Readiness Index (2015). ?????? ???????: <http://reports.weforum.org/global-information-technology-report-2015/economies/#indexId=NRI&economy=UKR> [Accessed 25 Aug. 2017].
 43.♦Nonaka, Y. Suginishi, Y., Lengyel, A., & Katsumura, Y. (2015, August) The S-Model: A digital manufacturing system combined with autonomous statistical analysis and autonomous discrete-event simulation for smart manufacturing. IEEE International Conference on Automation Science and Engineering (CASE) (pp. 1006-1011). Gothenburg: IEEE.
 44. Reimann, M., & Ruckriegel, C. (2017). Road2CPS Priorities and Recommendations for Research and Innovation in Cyber-Physical Systems. Stuttgart: Steinbeis-Editions.
 45. Saraee, M. How can companies start implementing the Smart Industry concept? ?????? ???????: https://www.smart-industry.nl/site/assets/files/2158/how_can_companies_start_implementing_the_smart_industry_concept.pdf [Accessed 08 Sept. 2017].
 46. Smart Enterprise demo for manufacturing. Pharaos Navigator. ?????? ??-?????: <https://enterprise.win2biz.com/static/content/en/525/Explaining-Enterprise-Model.html> [Accessed 08 Sept. 2017].
 47.♦The 2016 IMD World Competitiveness Scoreboard. ?????? ???????: <http://www.imd.org/globalassets/wcc/docs/scoreboard-2016.pdf> [Accessed 08 Sept. 2017].
 48. Yin, S., & Kaynak, O. (2015). Big Data for Modern Industry: Challenges and Trends. Proceedings of the IEEE, 2 Vol. 103, pp. 143-146.
 49. Zaitsev, D.A. (2012). Universal Petri Net. Cybernetics and Systems Analysis, Vol. 48, Issue 4, pp. 498-511.
 50. Zhou, Z., Xie, S., & Chen, D. (2012). Fundamentals of Digital Manufacturing Science. London: Springer-Verlag London Limited.