

Ministry of Education and Science of Ukraine
V. N. Karazin Kharkiv National University
Department of International Economic Relations and Logistics

“APPROVED”

Director of the Educational and Scientific Institute
“Karazin Institute of International Relations
and Travel Business”
Mykola RYSAREVSKYI



28th August 2026

WORK PROGRAM

TECHNOLOGIES OF SOCIAL DEVELOPMENT

level of higher education third (educational and research)

field of study C Social Sciences, Journalism, Information and International Relations

specialty C1 Economics and International Economic Relations (by specializations)

specialization C1.02 International Economic Relations

educational program International Economic Relations

status of the discipline: elective

Education and Research Institute “Karazin Institute of International Relations and Travel Business”

2026 / 2027 academic year

The syllabus was recommended for approval by the Academic Council of the Educational and Scientific Institute "Karazin Institute of International Relations and Travel Business" August 27, 2026, Minutes No. 1

PROGRAM DEVELOPER: Ihor MATIUSHENKO,
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The program was approved at the meeting of the Department of International Economic Relations and Logistics
Minutes No. 1 dated 26 August 2026

Head of the Department


_____ Anna ZAITSEVA

The program was agreed with the guarantor of the educational and research program "International Economic Relations" for the third (educational and research) level of higher education

Guarantor of the educational and research program "International Economic Relations" for the third (educational and research) level of higher education


_____ Olena DOVGAL

The program was agreed by the Scientific and Methodological Commission of the Education and Research Institute "Karazin Institute of International Relations and Travel Business"

Minutes No. 1 dated 27 August 2026

Head of the Scientific and Methodological Commission


_____ Hanna PANASENKO

Introduction

The program for the course "Technologies of Social Development" has been developed in accordance with the educational-scientific PhD program in "International Economic Relations" (Specialty: C1 Economics and International Economic Relations; Specialization: C1.02 International Economic Relations).

1. Course Description

1.1. The aim of the course is to build knowledge and skills regarding the theoretical aspects of social development technologies and to acquire practical skills in applying technological forecasting of social development to establish priorities for the scientific and innovative development of countries worldwide - and Ukraine specifically - in the context of the new industrial revolution.

1.2. The primary objectives of the course are for students to acquire knowledge enabling them to:

- define the essence of and classify global problems, and understand the development of key economic growth theories;
- understand the essence of innovation-based theories of economic development;
- analyze the transformation of the economy and society on an innovation-driven basis;
- understand the essence of the innovation process and the triad of technological progress;
- determine the impact of technological innovations on societal development;
- apply the convergence of knowledge, technology, and society as a mechanism for addressing global problems;
- define the essence and characteristics of the 21st-century new industrial revolution and advanced manufacturing technologies;
- assess the impact of the new industrial revolution on the economy, business, national and global spheres, society, and the individual;
- examine global technological forecasts from leading nations;
- evaluate prospects for developing scientific-innovation potential and high-tech sectors in Ukraine;
- transformation of the business model of an innovative enterprise in the context of the new industrial revolution;
- improvement of organizational mechanisms for scientific and technological development and Ukraine's implementation of European integration reforms in the sphere of science and technology.

1.3. Number of credits:

Full-time study: – 3 credits

1.4. Total number of hours:

Full-time study: – 90 hours

1.5. Characteristics of the academic discipline
By choice
Full-time form of study
Year of preparation
2nd
Semester
4rd
Lectures
13 hours
Practical, seminar classes
26 hours
Independent work
51 hours
Individual tasks

1.6. List of competencies developed by this course:

- General competencies:

GC 1. Ability to exercise one's rights and responsibilities as a member of society, to understand the values of civil (democratic) society and the need for its sustainable development, the rule of law, and human and civil rights and freedoms in Ukraine.

GC 4. Ability to apply knowledge in practical situations.

GC 6. Ability to communicate in the state language both orally and in writing.

- Special (professional) competencies:

PC 2. Ability to analyze the results of an organization's activities and compare them with the factors influencing its external and internal environment.

PC 12. Ability to analyze and structure organizational problems and formulate well-founded decisions.

PC 15. Ability to develop and demonstrate leadership qualities and behavioral skills.

1.7. Intended learning outcomes:

PLO 1. Know one's rights and responsibilities as a member of society and understand the values of civil society, the rule of law, and human and civil rights and freedoms in Ukraine.

PLO 4. Demonstrate skills in identifying problems and substantiating managerial decisions.

PLO 6. Demonstrate skills in searching for, collecting, and analyzing information and calculating indicators to substantiate managerial decisions.

PLO 7. Demonstrate organizational design skills.

PLO 15. Demonstrate the ability to act in a socially responsible and civically conscious manner based on ethical considerations (motives), respect for diversity, and interculturality.

PLO 19. Identify areas of innovative development of an enterprise and assess the prospects of innovation projects.

1.8. Prerequisites: none.

2. Thematic Plan of the Course

SECTION 1. Theoretical Aspects of the Implementation of Social Development Technologies

Topic 1. Global Problems and Innovative Theories of Economic Development

1.1. Global problems of humankind

1.2. Main concepts and theories of the economic development of modern society

1.3. Evolution of the theory of modern society

1.4. Evolution of the theory of technological change

1.5. Modern theories of the information economy

1.6. Comparative characteristics of current techno-economic paradigms aimed at addressing global problems

Topic 2. Innovation-Based Transformation of the Economy and Society

2.1. Main types and models of economic development. The concepts of developed and developing countries

2.2. Relationship between innovation and modernization. Leapfrogging. Comparison of traditional society with societies characterized by catching-up and advanced types of economic development

2.3. Concept and types of transformations. Technological revolutions and technological upheavals. The global technological crisis of the early twentieth century. Specific features of the global technological revolution of the twenty-first century. Institutional and structural transformations of the economic system

2.4. Economic essence and classification of innovations. Motives, types, degree of novelty, and spatial scope of innovations. Sustaining and disruptive innovations

2.5. Stages of the innovation process. Relationship between novelty and innovation, an innovative product and innovation output. The triad of technological progress: inventions, innovations, and

investments. Definition, subjects, and objects of innovation activity. Concepts of an innovative enterprise and innovation potential

2.6. The concept of “technology.” Interrelationship between the technological and economic potential of innovations. Definition, life cycle, and structure of a technological paradigm. Periodization of the major waves of innovation-driven development

Topic 3. Impact of Technological Innovations on Social Development. Convergence of Knowledge, Technology, and Society as a Mechanism for Addressing Global Problems

3.1. Concepts of technology convergence and technological convergence. Map of emerging technology convergence

3.2. Convergence of NBIC technologies as a key factor of the sixth technological paradigm. Cross-sectoral nature of NBIC technology convergence

3.3. Concept of the convergence of knowledge, technology, and society (CKTS). Convergence mechanisms. Phases of convergence

3.4. Platform of fundamental NBIC tools. Synergistic effect of NBIC technology convergence

3.5. Human, Earth, and societal dimensions of the CKTS platform

Topic 4. The New Industrial Revolution of the Twenty-First Century and Advanced Manufacturing Technologies

4.1. Features and principal concepts of the new industrial revolution of the twenty-first century. Industry

4.0. Definition, characteristic features, and priority areas for the development of advanced manufacturing technologies. Organic integration of NBIC technology convergence and Smart TEMP factors in industrial production

4.2. Megatrends: physical, digital, and biological dimensions. Expected tipping points by 2025.

4.3. Impact of the new industrial revolution on the modern economy. Impact of Industry 4.0 on business development. Relationship between Industry 4.0 and the national and global dimensions. Impact of the new industrial revolution on society and the individual

SECTION 2. Prospects for Social Development in the Context of the New Industrial Revolution in the Countries of the World and Ukraine

Topic 5. Global Technology Forecasts of Leading Countries and Ukraine

5.1. International experience in conducting foresight studies. Principal foresight methods. Global technology forecasts and the development of convergent technologies in developed countries—the United States, the EU, Japan, and Korea

5.2. Forecasts of scientific and technological development and convergent technologies in developing countries: China, India, and Russia. Forecast assessments of the development of breakthrough manufacturing technologies across the world

5.3. Foresight forecasting of the technological development of Ukraine’s economy

5.4. Practices for identifying high-technology industries in the countries of the world and Ukraine. Application of breakthrough technologies in medicine and Ukraine’s agro-industrial complex. Development of nanotechnologies, nanomaterials, and new materials in Ukraine. Convergent technologies in Ukraine’s ICT and electronics sectors. Addressing Ukraine’s energy and environmental problems through convergent technologies. Modernization of Ukraine’s aerospace sector using convergent technologies

Topic 6. Technology Transfer, Innovation Implementation Mistakes, Entrepreneurial Mistakes, and the Art of Raising Capital. Innovative Transformation of Business Models in the Context of Industry 4.0

6.1. Essence, main phases, and mechanisms of technology transfer. Common mistakes in innovation implementation, standard pitfalls in implementing an idea, and selection of the core competencies concept. Major entrepreneurial mistakes. The art of raising capital. Rules for startup presentations

6.2. Key elements and tools for business model development: components and canvas, value creation network, value proposition, revenues, and pricing

6.3. Innovative transformation of business models in the context of Industry 4.0. Business Model Navigator

- 6.4. Change management, Balanced Scorecard, performer's roadmap, and "discovery-driven" planning
Topic 7. Organizational Mechanisms of Scientific and Technological Development. Ukraine's European Integration Reforms in Science and Technology
- 7.1. Concept and principal components of research and innovation infrastructure. National innovation systems. Modern mechanisms for interaction among infrastructure elements: clusters, technology platforms, and innovation ecosystems. Regional smart specialization strategy
- 7.2. Formation of the common European Research Area and the Ukrainian national research area. Implementation of regional smart specialization strategies in Ukraine
- 7.3. Implementation by Ukraine of European integration reforms in science and technology

3. Structure of the Course

Sections and Topics	Number of hours			
	Total	including		
		Lectures	Seminar Classes	Independent Study
SECTION 1. Theoretical Aspects of the Implementation of Social Development Technologies				
Topic 1. Global Problems and Innovative Theories of Economic Development	10	1	3	6
Topic 2. Innovation-Based Transformation of the Economy and Society	11	2	3	6
Topic 3. Impact of Technological Innovations on Social Development. Convergence of Knowledge, Technology, and Society as a Mechanism for Addressing Global Problems	12	2	4	6
Topic 4. The New Industrial Revolution of the Twenty-First Century and Advanced Manufacturing Technologies	13	2	4	7
<i>Total for Section 1</i>	46	7	14	25
SECTION 2. Prospects for Social Development in the Context of the New Industrial Revolution in the Countries of the World and Ukraine				
Topic 5. Global Technology Forecasts of Leading Countries and Ukraine	14	2	4	8
Topic 6. Technology Transfer, Innovation Implementation Mistakes, Entrepreneurial Mistakes, and the Art of Raising Capital. Innovative Transformation of Business Models in the Context of Industry 4.0	14	2	4	8
Topic 7. Organizational Mechanisms of Scientific and Technological Development. Ukraine’s European Integration Reforms in Science and Technology	16	2	4	10
<i>Total for Section 2</i>	44	6	12	26
Total hours	90	13	26	51

4. Topics of seminar (practical) classes

№ topic	Topic Title	Number of hours
1	Global Problems and Innovative Theories of Economic Development	1
2	Innovation-Based Transformation of the Economy and Society	2
3	Impact of Technological Innovations on Social Development. Convergence of Knowledge, Technology, and Society as a Mechanism for Addressing Global Problems	2

4	The New Industrial Revolution of the Twenty-First Century and Advanced Manufacturing Technologies	2
5	Global Technology Forecasts of Leading Countries and Ukraine	2
6	Technology Transfer, Innovation Implementation Mistakes, Entrepreneurial Mistakes, and the Art of Raising Capital. Innovative Transformation of Business Models in the Context of Industry 4.0	2
7	Organizational Mechanisms of Scientific and Technological Development. Ukraine's European Integration Reforms in Science and Technology	2
	Total	13

5. ASSIGNMENTS FOR INDEPENDENT WORK

№ topic	Topic Title	Number of hours
1	Global Problems and Innovative Theories of Economic Development Tasks:	6
2	Innovation-Based Transformation of the Economy and Society	6
3	Impact of Technological Innovations on Social Development. Convergence of Knowledge, Technology, and Society as a Mechanism for Addressing Global Problems	6
4	The New Industrial Revolution of the Twenty-First Century and Advanced Manufacturing Technologies	7
5	Global Technology Forecasts of Leading Countries and Ukraine	8
6	Technology Transfer, Innovation Implementation Mistakes, Entrepreneurial Mistakes, and the Art of Raising Capital. Innovative Transformation of Business Models in the Context of Industry 4.0	8
7	Organizational Mechanisms of Scientific and Technological Development. Ukraine's European Integration Reforms in Science and Technology	10
	Total	51

6. INDIVIDUAL TASKS

Not provided for in the curriculum.

7. TEACHING METHODS

Lecture as a combination of verbal, visual, inductive, deductive, explanatory and illustrative teaching methods, conversation, discussion.

Practical learning as a combination of case studies, problem-based approach, heuristic, research and project methods.

Application of interactive teaching tools through the use of LMS Moodle learning platforms and their capabilities, in particular: interactive technologies of cooperative learning, interactive technologies of collective and group learning, situational modeling technologies, technologies for processing discussion questions, work in small groups, dialogue, synthesis of thoughts, joint project, information search, circle of ideas, brainstorming, case method, method of determining a position, defending a given position, comparison of alternative positions, discussion, debate.

8. Control methods

Assessing the level of knowledge is an integral part of the educational process. The evaluation of doctoral students' knowledge in the course "Technologies of Social Development" takes into account all types of classes prescribed by the curriculum. Knowledge and skills are assessed through continuous, interim, and final evaluations.

The following assessment methods are used during the "Technologies of Social Development" course:

- continuous assessment takes place during seminars and practical classes through oral responses, problem-solving, and the completion of practical and analytical tasks;
- interim assessment is conducted via tests;
- final assessment consists of a pass/fail exam covering the entire course.

The maximum score for continuous assessment is 60 points.

Scoring scale for the continuous assessment of students:

Continuous assessment (mastery of specific topics) during practical classes is conducted in the form of oral questioning or brief written tests, as well as student presentations and reports during the discussion of course topics.

For each topic, continuous assessment is carried out through oral questioning and student presentations on pre-assigned questions. The criteria for assessing knowledge during ongoing evaluation include the successful mastery of material and skills acquired during lectures and practical classes. This encompasses the student's ability to grasp the conceptual framework, demonstrate generalized thinking skills, present course material logically and comprehensively, apply a creative approach to problem-solving, participate actively in practical sessions, demonstrate knowledge during in-class questioning, and independently study the topics.

For a presentation during a seminar, a student can earn between 1 point (for adding to or clarifying another student's presentation) and 4 points (for a detailed analysis of the topic incorporating data from academic articles, statistical materials, etc.).

Final semester assessment takes place during the credit test. The maximum score for successfully completing the credit test tasks is 40 points. The time allowed is up to 60 minutes.

The student completes a test-based assignment (the exam paper contains 40 multiple-choice questions, with 1 point awarded for each correct answer).

9. Scoring scheme

For the final semester control during the examination work

Continuous assessment (total score for topics), of which:							Credit Assignment	Sum
T1.	T2.	T3.	T4.	T5.	T6.	T7.	40	100
60								

T1, T2 ... - topics of the sections.

Ongoing assessment takes place during seminar sessions, accounting for a total of up to 60 points, distributed as follows: active participation and informational presentations during seminars – up to 10 points; preparation of creative assignments involving multimedia presentations – up to 50 points (2 presentations worth up to 25 points each).

Criteria for the ongoing assessment of student knowledge:

Informational presentations during seminar sessions:

- 8–10 points – the student prepares an informational report relevant to the seminar (practical) topic; demonstrates full command of the course material; presents it fluently, independently, and with sound argumentation during oral presentations and written responses; explores the content of theoretical issues and practical tasks in depth and comprehensively, utilizing both required and supplementary literature; and actively contributes to the discussion of key issues.
- 5–7 points – the student generally commands the course material and presents its main content during oral presentations and written responses, but lacks deep, comprehensive analysis, justification, and argumentation, and fails to utilize the necessary literature. When addressing certain issues, the student lacks sufficient depth and argumentation, and makes some significant inaccuracies and errors.

- 3–4 points – the student does not fully command the course material. Presents answers in a fragmentary and superficial manner (lacking argumentation and justification) during oral and written presentations; fails to adequately cover the content of theoretical questions and practical tasks, making significant inaccuracies; does not participate in discussions of complex issues; and attends classes irregularly.
- 1–2 points – the student attempts to work on the topic during seminar (practical) classes but lacks command of the course material, is unable to present it, and does not understand the content of theoretical questions and practical tasks.
- 0 points – the student does not participate in the seminar class or does not attend classes.

Preparation of creative assignments with multimedia presentations:

- 20–25 points – the student actively prepares and delivers a creative assignment with a presentation on the topic during seminar classes; demonstrates full command of the course material; presents it fluently, independently, and with sound argumentation; provides a deep and comprehensive analysis of the presentation content using both required and supplementary literature; and answers questions from other students and the instructor.
- 15–19 points – the student generally demonstrates command of the course material during the presentation and conveys its main content, but lacks deep, comprehensive analysis, justification, and argumentation, and does not use supplementary literature. The presentation lacks sufficient depth and argumentation, and contains some significant inaccuracies and errors.
- 10–14 points – the student does not demonstrate full command of the course material during the presentation. Covers the content of the presentation only fragmentarily and superficially (lacking argumentation or justification), makes significant inaccuracies, and is unable to answer questions from other students or the instructor.
- 1–9 points: The student prepared the creative assignment but did not present it during the seminar; lacks command of the course material; does not understand the topic and failed to cover its content.
- 0 points: The student did not prepare the creative assignment and did not present it during the seminar, or does not attend classes.

A student is eligible for the final assessment if they have earned at least 30 points based on the results of ongoing assessments.

In the event of academic dishonesty during the exam, the student receives a grade of zero for the entire assessment.

Example of final semester assessment (pass/fail test).

The student completes a test-based assignment (the exam paper contains 40 test questions; the student receives 1 point for each correct answer).

Assessment criteria for all types of assignments (ongoing and final assessments) are provided in the relevant sections of the "Social Development Technologies" distance learning course: <https://dist.karazin.ua/moodle/course/view.php?id=2935>

GRADING SCALE

Total points for all types of learning activities during the semester	Grade for the pass/fail requirement
90 – 100	credited
70-89	
50-69	
0-49	uncredited

Criteria for Assessing Academic Achievement

During the study of this course, the use of artificial intelligence (AI) technologies is governed by the Artificial Intelligence Technology Use Policy of V. N. Karazin Kharkiv National University.

The following AI usage models apply to this course:

1. "AI Prohibited" Model.

The use of AI technologies is not permitted during assessment activities designed to evaluate a student's individual knowledge and competencies—specifically oral questioning, modular tests, and exams (or pass/fail assessments), unless otherwise specified by the instructor, or for other types of assessment where the instructor has restricted AI usage.

2. "AI as Assistant" Model.

When preparing for practical classes or completing individual assignments, essays, analytical reviews, and other written work, students may use AI to: search for and organize information; select and conduct a preliminary analysis of academic sources; explain complex concepts; improve text structure; check grammar, style, and formatting; and generate ideas, work outlines, or examples.

The final text of the work, conclusions, analysis, interpretation of results, and decisions made must be prepared independently by the student.

3. "AI as Tool" Model.

For specific laboratory, practical, project-based, or research assignments, the use of AI technologies may be a mandatory component of the task. In such cases, students may use generative AI models for: data analysis and preparation; generating, analyzing, and optimizing program code; comparing the outputs of different AI models; creating visualizations, diagrams, or images; analyzing large datasets; and conducting experiments using modern artificial intelligence tools.

All results obtained using AI are subject to critical analysis, verification, and refinement by the student.

Declaration of AI use.

When using artificial intelligence technologies, the student is required to specify: the name of the AI service or model; the date of use; and the nature of the assistance (e.g., idea generation, information retrieval, data analysis, code generation, text editing).

Upon the instructor's request, the student must provide the prompts used or explain how the AI tools were utilized.

Undeclared use of artificial intelligence technologies or the submission of AI-generated material as one's own academic work is considered a violation of academic integrity principles, in accordance with the University's internal regulations.

Recognition of Non-Formal Education

Students may earn additional points for successfully completing distance learning courses or training sessions on leading educational platforms, provided the content is thematically relevant to the course and aligns with the total credit value.

Examples of relevant non-formal education include:

- online courses (e.g., Coursera, Prometheus) with content related to the subject matter of the course;
- participation in certified training sessions and seminars covering topics related to the course content;
- certified programs on topics related to the course content, conducted by international organizations or universities.

Conditions for recognition:

- The student must submit an official document (certificate or statement of completion) to the instructor confirming successful completion of the course.
- The course must be approved by the instructor; it is recommended to discuss the choice of course in advance.

Each request is reviewed on an individual basis. The procedure for recognizing non-formal education outcomes is carried out in accordance with the **Regulations on the Recognition of Learning Outcomes Obtained through Non-Formal Education at V.N. Karazin Kharkiv National University**. Decisions are made by the Academic and Methodological Commission of the Karazin Institute of International Relations and Tourism Business based on the documentation submitted by the student.

10. RECOMMENDED READING:

Basic literature

1. Матюшенко І.Ю. Дистанційний курс «Технології суспільного розвитку» [Електронний ресурс]. – Режим доступу: <https://dist.karazin.ua/moodle/course/view.php?id=2935>
2. Alghamdi, A.S. (2026). Smart Factories, Smarter Research: A Critical Review of Manufacturing 4.0 Technologies, Sustainability, and the Road to Industry 5.0. *Journal of Manufacturing and Materials Processing*. 10(8). 308. DOI: 10.3390/jmmp10080308.
3. Agarwal, A. and Ojha, R. (2024). Prioritizing implications of Industry-4.0 on the sustainable development goals: A perspective from the analytic hierarchy process in manufacturing operations. *Journal of Cleaner Production*. 444. 141189. DOI: 10.1016/j.jclepro.2024.141189.
4. Grybauskas, A., Stefanini, A. and Ghobakhloo, M. (2022). Social sustainability in the age of digitalization: A systematic literature review on the social implications of Industry 4.0. *Technology in Society*. 70. 101997. DOI: 10.1016/j.techsoc.2022.101997.
5. Integrating Industry 4.0 for enhanced sustainability: Pathways and prospects (2025). *Sustainable Production and Consumption*. 54. pp. 149–189. DOI: 10.1016/j.spc.2024.12.012.
6. Jan, Z., Ahamed, F., Mayer, W., Patel, N., Grossmann, G., Stumptner, M. and Kuusk, A. (2023). Artificial intelligence for industry 4.0: Systematic review of applications, challenges, and opportunities. *Expert Systems with Applications*. 216. 119456. DOI: 10.1016/j.eswa.2022.119456.
7. Khan, I.S., Ahmad, M.O. and Majava, J. (2023). Industry 4.0 innovations and their implications: An evaluation from sustainable development perspective. *Journal of Cleaner Production*. 405. 137006. DOI: 10.1016/j.jclepro.2023.137006.
8. Ocelík, V., Kolk, A. and Ciulli, F. (2023). Multinational enterprises, Industry 4.0 and sustainability: A multidisciplinary review and research agenda. *Journal of Cleaner Production*, 413, 137434. DOI: 10.1016/j.jclepro.2023.137434.
9. de Orte, I., Chalmeta, R. and dos Santos Silva, J. (2026). Negative Impacts on Sustainability of Industry 4.0 Disruptive Technologies and Actions to Mitigate them: a Systematic Literature Review. *Journal of the Knowledge Economy*. 17. pp. 8879–8916.
10. Ferreira, J.J., Lopes, J.M., Gomes, S. and Rammal, H.G. (2023). Industry 4.0 implementation: Environmental and social sustainability in manufacturing multinational enterprises. *Journal of Cleaner Production*. 404. 136841. DOI: 10.1016/j.jclepro.2023.136841.
11. Ghannouchi, I. (2023). Examining the dynamic nexus between industry 4.0 technologies and sustainable economy: New insights from empirical evidence using GMM estimator across 20 OECD nations. *Technology in Society*. 75. 102408. DOI: 10.1016/j.techsoc.2023.102408.
12. Picinin, C.T., Pedroso, B., Arnold, M., Klafke, R.V. and Pinto, G.M.C. (2023). A Review of the Literature about Sustainability in the Work of the Future: An Overview of Industry 4.0 and Human Resources. *Sustainability*. 15(16). 12564. DOI: 10.3390/su151612564.
13. Rikala, P., Braun, G., Järvinen, M., Stahre, J. and Hämmäläinen, R. (2024). Understanding and measuring skill gaps in Industry 4.0 – A review. *Technological Forecasting and Social Change*. 201. 123206. DOI: 10.1016/j.techfore.2024.123206.
14. Shabur, M.A. (2024). A comprehensive review on the impact of Industry 4.0 on the development of a sustainable environment. *Discover Sustainability*. 5. Article 97.

Supplementary literature

1. Брітес Г., Фабіан Айяла Н., Даленогаре Л., Герман Франк А. Очікуваний внесок технологій промисловості 4.0 для промислового виконання. *Міжнародний журнал економіки виробництва*. 2022. С. 383–394.

2. Гобахлю М. Унікальні і прогресивні технології як передумова четвертої промислової революції. *Сучасні тенденції в економіці та управлінні: новий погляд*. 2022. С. 273–275.

3. Завербний А. С., К. Р. Сало К. Р. Проблеми та перспективи розвитку Індустрії 4.0 в Україні за умов євроінтегрування. *Менеджмент та підприємництво в Україні: етапи становлення та проблеми розвитку*. 2022. № 2 (8). С. 374-382.

11. Links to online information resources, video lectures, and other methodological materials

1. European Commission – Advanced Manufacturing. URL: https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/advanced-manufacturing_en
2. European Commission – Digitalising Industry. URL: <https://digital-strategy.ec.europa.eu/en/policies/digitising-industry>
3. European Commission – Digital Transformation of EU Industry. URL: https://single-market-economy.ec.europa.eu/industry/strategy/digital-transformation_en
4. European Commission – Industry 5.0. URL: https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/industry-50_en
5. European Commission – Research and Innovation: Industrial Research and Innovation. URL: [Industrial Research and Innovation](#)
6. Interoperable Europe Portal – Digitisation of European Industry 2026. URL: <https://interoperable-europe.ec.europa.eu/collection/rolling-plan-ict-standardisation/digitisation-european-industry-rp-2026>
7. National Institute of Standards and Technology (NIST) – Smart Manufacturing. URL: <https://www.nist.gov/publications/2026-roadmap-artificial-intelligence-and-machine-learning-smart-manufacturing>
8. Plattform Industrie 4.0 – Germany. URL: [Plattform Industrie 4.0](#)
9. United Nations Industrial Development Organization (UNIDO) – Industry 4.0. URL: <https://www.unido.org/learning-resources/industry-40>
10. UNIDO – Smart Manufacturing & Industry 4.0. URL: <https://www.unido.org/learning-resources/smart-manufacturing-industry-40>
11. UNIDO – Industrial Development Report 2026. URL: <https://www.unido.org/idr/idr2026>
12. World Bank – Europe 4.0: Addressing Europe's Digital Dilemma. URL: <https://www.worldbank.org/en/region/eca/publication/addressing-europes-digital-dilemma>.