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DIRECTIONS OF ARTIFICIAL INTELLIGENCE IMPLEMENTATION AT ECONOMY OF UKRAINE AND POLAND[1]

НАПРЯМИ ВПРОВАДЖЕННЯ ШТУЧНОГО ІНТЕЛЕКТУ В ЕКОНОМІЦІ УКРАЇНИ ТА ПОЛЬЩІ

Summary. The purpose of research is to form directions of artificial intelligence technologies' implementation at economy of Ukraine and Poland. To define and analyze literature streams about artificial intelligence technologies' implementation in economy it is used methods of comparison, analysis, synthesis. The SWOT analysis method is employed to identify the strengths, weaknesses, opportunities, and threats associated with the implementation of artificial intelligence technologies in Poland and Ukraine. Brainstorming and modeling methods are applied to develop strategic directions for the implementation of AI technologies in both countries. The SWOT analysis of artificial intelligence implementation in Poland and Ukraine reveals distinct characteristics. Poland's artificial intelligence environment is driven by legislative regulation and substantial startup funding, while Ukraine's environment relies on the performance of foreign companies' tasks and university project activities. The study establishes that the background of artificial intelligence development in a country is a result of government agenda and startup activities. The research contributes to the identification and understanding of potential pathways for the utilization of artificial intelligence in the economies of Poland and Ukraine for national development.

Keywords: artificial intelligence, diffusion, infrastructure, model, readiness of society, SWOT analysis, technology.

Анотація. Актуальність дослідження пов'язана з посиленою увагою науковців, урядів країн до можливостей трансформації національних економік, в тому числі окремих галузей на основі технологій штучного інтелекту. Уряди держав та міжнародні компанії активно вивчають, як штучний інтелект може підвищити ефективність виробництва, поліпшити обслуговування клієнтів та сприяти економічному зростанню. Метою дослідження є формування напрямків впровадження технологій штучного інтелекту в економіці України та Польщі, зокрема, на основі аналізу наукових джерел та оцінки національних ініціатив у цій

сфері. Застосовано SWOT-аналіз для визначення сильних і слабких сторін, можливостей і загроз, пов'язаних із впровадженням штучного інтелекту в національні господарства країн, що уможливило ідентифікацію викликів та сформувати перспективи імплементації технологій. Визначено основні ніші наукових досліджень, пов'язаних із впровадженням технологій штучного інтелекту, що дозволило систематизувати підходи до їх впровадження. Науковці першої ніші присвячують дослідження питанням використання штучного інтелекту в процесах формування державної політики. Друга ніша наукових досліджень включає питання політики щодо штучного інтелекту, що охоплює аналіз поточного стану ініціатив у сфері штучного інтелекту та перспективи його розвитку в різних країнах. Третій напрямок наукових досліджень щодо впровадження штучного інтелекту фокусується на взаємозв'язках штучного інтелекту і економічного зростання національних економік. Обґрунтовано, що середовище штучного інтелекту в Польщі активно розвивається завдяки чіткому законодавчому регулюванню і значному фінансуванню стартапів, тоді як в Україні сфера розробок штучного інтелекту функціонує на основі замовлень іноземних компаній та проєктній діяльності в університетах. Визначено напрямки впровадження технологій штучного інтелекту в економіці України та Польщі, що можуть бути використані для розроблення програм імплементації штучного інтелекту в розрізі регіонів України та Польщі, в цілому національного господарства.

Ключові слова: готовність суспільства, дифузія, інфраструктура, модель, технологія, штучний інтелект, SWOT аналіз.

Problem statement. Artificial intelligence (AI) continues to expand opportunities for progress of the achievement of the country's development. AI has transformative potential. Also AI is an emerging technology that poses challenges to understand it evolution [3; 8; 24].

AI changes landscape of industry. In manufacturing, AI-enabled technologies are changing the way products are designed and made. Generative design technologies, powered by AI, give manufacturers a strong tool to optimize their product designs. Widespread use of this type of AI-enabled manufacturing technology can help create more sustainable products in a broad array of industries [1; 4; 6; 15; 17].

That why it is important to understand in what directions have to be implemented AI for achieving greater benefits for country's development.

Process of forming AI development directions is open question for all countries today. Anyone country has no synergy effect of AI technologies, mostly is testing processes. But some countries, as USA, China, Germany, United Kingdom and South Korea developed AI base legislation and infrastructure conditions for fast AI technologies production last years [2; 6; 12]. And such difference in AI base between countries will form in closer future development and GDP gaps.

Analysis of recent research and publications. Theoretical basic concepts of investigation are R. Solow's model (in the long run economic growth is driven exclusively by technological changes); J. Schumpeter's theory of endogenous economic growth (difference in the rates of economic growth deals with different levels of adaptation of technological progress and the diffusion of new technologies).

By Wang P., artificial intelligence means devices and software that imitate cognitive functions of the human mind, such as: learning and decision-making, inference, speech recognition and articulation of thoughts, problem solving, object recognition as well as domains of knowledge pertaining to neural networks, fuzzy logic, artificial life and robotics. It is both devices and software that arose as a result of human work, and not as a result of biological evolution itself. Artificial Intelligence is also the machines' unaided ability to solve various problems without using a pre-programmed algorithm of action coded by humans [36].

The important question for investigation is what streams of literature related to AI technologies implementation we have today. We determine three main focuses of literature streams related to AI technologies implementation. First one is "AI and public policy", in which researchers (Butt J., Noordt C., Misuraca G., Sharma M. et al.) argues how AI can use in public policy making [10; 28; 32]. Second one is "AI policy". This is literature stream includes analysis of current state of AI initiatives and future perspectives in different countries [7; 14; 19–20; 35]. Third literature stream is "Artificial Intelligence and growth". Authors (Lu Chia-Hui, Stirling R., Ulnicane I., Wang L. et al.) explain AI impact to economic growth and possible AI effects in their papers [23; 34–35; 37].

Generally AI is emerging technology and it is difficult to prognosis direct and indirect effects of it using and how it can changes economy landscape. But modeling of AI technologies implementation gives stronger basis for decision making in AI field and country's development.

Artificial intelligence is gaining interest among economists dealing with economic growth and economic policy – also in Poland and Ukraine. What is the significance of artificial intelligence for economic development? Is it right to identify AI as a priority technology for national development today? Positive answers to these questions imply the necessity to form directions of artificial intelligence technologies implementation in Poland and Ukraine for economic development.

Thus artificial intelligence is determined as important technology for development of country

today in EU, China, USA and other countries [6; 15; 17]. It is no prevalence of artificial intelligence technologies at Poland's and Ukraine's economies. That why it needs to form directions for country's artificial intelligence technologies' implementation for Ukraine and Poland. As result, stronger and stable economy with AI technological background of Ukraine and Poland will be constructed.

The purpose of the article to form directions of artificial intelligence implementation at economy of Ukraine and Poland

Methodology. Our analysis combines both top-down and bottom-up analysis. There are four steps in our methodology.

Step 1 is to define and analyze literature streams about artificial intelligence technologies' implementation in economy (methods: comparison, analysis, synthesis).

Step 2 is to determine strengths, weaknesses, opportunities and threats of Poland's and Ukraine's artificial intelligence technologies' implementation (method: SWOT analysis).

Step 3 is to develop directions of Poland's and Ukraine's artificial intelligence technologies' implementation (methods: brainstorming, modeling).

Among the different methodologies used in the research, we can mention data analysis, desk research, and literature review. In terms of data, studies are based on official statistics.

Summary of the main results of the study. There are such dimensions that we worked out for understanding strengths and weaknesses of implementing artificial intelligence technologies in Poland and Ukraine [5; 8–9; 13; 16; 18; 21-22; 26; 31; 33]: 1) regulatory framework; 2) Infrastructure level; 3) level of higher education; 4) statistic's country system; 5) connection with European Union's approach; 6) location of AI companies; 7) society readiness to use AI; 8) number of registered AI patents; 9) using AI technologies in manufacturing; 10) development of AI startups culture; 11) ecological and digital country's development; 12) leveraging AI to serve people and business; 13) intellectual AI property rights; 14) number of AI startups; 15) AI startups directions; 16) ethics regulatory framework for AI.

SWOT-analysis of Poland's and Ukraine's artificial intelligence technologies' implementation is represented in Table 1 and Table 2.

Table 1 – SWOT-analysis of Poland's Artificial Intelligence Technologies' Implementation

S	W
1. Regulatory framework for AI 2. High infrastructure level 3. High level of technological university education in Warsaw, Gdansk, Krakow, Poznan, Wroclaw regions 4. Strong statistic system of gathering data	1. Aligness AI readiness aims with the European Union's approach 2. Locations 85 % of AI companies in Warsaw, Gdansk, Krakow, Poznan, Wroclaw, Katowice urban regions 3. Low level of society readiness to use AI 4. Small number of registered AI patents
O	**T**
1. Using AI technologies in manufacturing 2. Development of AI startups culture 3. Twin ecological and digital country's development 4. Focus on leveraging AI to serve people and business	1. Intellectual AI property rights belong to foreign companies. 2. Small number of AI startups 3. AI startups in "light" directions (supervision physical activity, data analysis) 4. Absence of ethics regulatory framework for AI

Source: compiled by the authors

Table 2 – SWOT-analysis of Ukraine's' Artificial Intelligence Technologies' Implementation

S	W
1. Regulatory framework for AI 2. High infrastructure level 3. High level of physics and math school education 4. Market AI solutions	1. Have similar AI policy goals with the European Union's approach, but there are more nationally self-reliant 2. Locations 90 % of AI companies in Kyiv, Dnipro, Kharkiv, Lviv regions. 3. Low level of society readiness to use AI 4. Small number of registered AI patents
O	**T**
1. Using AI technologies in manufacturing 2. Development of AI startups funding programs 3. Digital country's development 4. Focus on leveraging AI to serve people and business	1. Intellectual AI property rights belong to foreign companies. 2. Small number of AI startups 3. AI startup's products are not used at internal market mostly 4. Weak statistical data collection system

Source: compiled by the authors

Thus process of artificial intelligence technologies' implementation in Poland and Ukraine has such the same elements:

S1: Regulatory framework for AI;

S2: High infrastructure level;

W2: Locations 85–90% of AI companies in 4–6 regions;

W3: Low level of society readiness to use AI;

W4: Small number of registered AI patents;

O1: Using AI technologies in manufacturing;

O4: Focus on leveraging AI to serve people and business;

T1: Intellectual AI property rights belong to foreign companies;

T2: Small number of AI startups.

There is main difference between process of artificial intelligence technologies' implementation in Poland and Ukraine in aspects of startups culture and statistical data collection system.

After identifying the strengths, weaknesses, opportunities, and threats of artificial intelligence technology implementation in Poland and Ukraine, we develop strategic directions for the implementation of artificial intelligence technologies in Poland (Table 3) and Ukraine (Table 4).

The AI landscape in Poland is founded on legislative regulation and the funding of AI startups. The Polish AI strategy offers strategic guidance and policy initiatives to develop a comprehensive AI ecosystem, with the following objectives: reforming the educational system and providing lifelong learning opportunities in AI-related fields; fostering the growth and innovation of AI companies through dedicated support for AI research, including the provision of sufficient financial resources; increasing national and international partnerships in AI; creating a data ecosystem with trustworthy, high-quality data and enhanced data exchange mechanisms; and strengthening digital infrastructure, regulatory frameworks, and test environments to promote AI innovation [25; 29].

The Polish strategy identifies the following priority sectors with the greatest potential to benefit from AI applications: industry, healthcare, transport and logistics, agriculture, energy, public administration, trade and marketing, construction, and cybersecurity [25; 29].

As part of the National Recovery Fund, Poland plans to invest in AI initiatives that support the goals of the European Green Deal. The focus is on the convergence of energy sources, transitioning factories to circular production, developing green and smart buildings and infrastructure, reducing transportation emissions, and launching the Space, Earth, and Seas Observatories for climate change. The aim is also to ensure sustainable development in collaboration with local governments.

The AI landscape in Ukraine is based on the performance of tasks for foreign companies and university project activities. The Ukrainian Strategy for Artificial Intelligence Development focuses on leveraging the country's existing AI capabilities to address strategic national priorities. The main objectives of the Ukrainian AI Strategy are to integrate AI technologies into every aspect of the country's development; to reform the education system to equip the next generation of Ukrainian tech companies with the AI talent and skilled human capital needed to propel the country forward; and to accelerate the adoption of AI technologies across the Ukrainian economy to maintain global competitiveness in sectors ranging from heavy industry to agriculture. The strategy primarily prioritizes digital infrastructure for AI (e.g., cloud resources, computing power), specific areas/sectors (e.g., new industrial policies, R&D targets for clean technology), and connectivity and digitalization [11; 30].

Conclusions. In conclusion, the analysis of possible AI implementation's direction in Poland and Ukraine reveals several commonalities and distinct differences. Both countries share similarities in their regulatory frameworks (S1), high infrastructure levels (S2), concentration of AI companies in specific regions (W2), low society readiness to use AI (W3), and a small number of registered AI patents (W4). Furthermore, both Poland and Ukraine actively utilize AI in manufacturing (O1) and focus on leveraging AI to serve people and businesses (O4). Intellectual AI property rights predominantly belong to foreign companies (T1), and there is a small number of AI startups (T2) in both countries.

However, the disparities emerge in the cultural aspects of startups and statistical data collection systems. Poland's AI environment is characterized by legislative regulation, robust startup funding, and a strategic approach to develop a holistic AI ecosystem, emphasizing education reform, financial support for AI research, and national and international partnerships. The Polish strategy identifies priority sectors such as industry, healthcare, transport, agriculture, energy, public administration, trade, marketing, construction, and cybersecurity.

On the other hand, Ukraine's AI environment relies on the performance of foreign companies' tasks and university project activities. The Ukrainian Strategy of AI Development concentrates on embedding AI technologies in various aspects of the country's development, reforming the education system, and accelerating the integration of AI throughout the economy. Key priorities include digital infrastructure for AI, specific sectors, and connectivity and digitalization.

Table 3 – Directions of Poland's Artificial Intelligence Technologies' Implementation

	O 1. Using AI technologies in manufacturing 2. Development of AI startups culture 3. Twin ecological and digital country's development 4. Focus on leveraging AI to serve people and business	T 1. Intellectual AI property rights belong to foreign companies. 2. Small number of AI startups 3. AI startups in "light" directions (supervision physical activity, data analysis) 4. Absence of ethics regulatory framework for AI
S 1. Regulatory framework for AI 2. High infrastructure level 3. High level of technological university education in Warsaw, Gdansk, Krakow, Poznan, Wroclaw regions 4. Strong statistic system of gathering data	S1O1 Diffusion AI technologies at industry S2O1 Development BTB AI applications S3O1 Implementations research AI findings into applications S4O1 Increasing number of supercomputers S1O2 Investments in emerging technologies S2O2 Development model AI as environment S3O2 Model „home" for AI unicorns S4O2 Diversification AI products and services S1O3 Forming large public AI firms S2O3 Development BTG AI applications S3O3 Increasing AI skills of workforce S4O3 Construct AI system as environment for decreasing ecological footprint S1O4 Development model AI as a service S2O4 Computer software spending S3O4 Cooperative AI clusters S4O4 Focus on BTC and BTB applications	S1T1 Development national AI tools of supplies S2T1 Forming large public AI firms S3T1 Model „home" for AI unicorns S4T1 Development model AI as a service S1T2 Forming AI skills of workforce S2T2 Development model AI as environment S3T2 Computer software spending S4T2 Implementations research AI findings into applications S1T3 Diversification AI products and services S2T3 Investments in emerging technologies S3T3 Diffusion AI technologies at industry S4T3 Forming large public AI firms S1T4 Adding AI ethics regulation to regulatory framework for AI S2T4 Development ethics regulatory framework for AI S3T4 Involving universities at development AI ethics regulation S4T4 Development AI ethics regulation based on statistical data
W 1. Aligness AI readiness aims with the European Union's approach 2. Locations 85 % of AI companies in Warsaw, Gdansk, Krakow, Poznan, Wroclaw, Katowice urban regions 3. Low level of society readiness to use AI 4. Small number of registered AI patents	W1O1 Cooperative AI clusters W2O1 Development model AI as environment W3O1 Increasing AI skills of workforce. Promotion of AI technologies to society W4O1 Forming large public AI firms W1O2 Model „home" for AI unicorns W2O2 Increasing AI skills of workforce W3O2 Development BTB and BTG AI applications W4O2 Development model AI as environment W1O3 Construct AI system as environment for decreasing ecological footprint W2O3 Computer software spending W3O3 Promotion of AI technologies to society W4O3 Development model AI as a service W1O4 Focus on BTC and BTB applications W2O4 Forming large public AI firms W3O4 Increasing AI skills of workforce. Promotion of AI technologies to society W4O4 Model „home" for AI unicorns	W1T1 Investments in emerging technologies W2T1 Forming large public AI firms W3T1 Increasing AI skills of workforce. Promotion of AI technologies to society W4T1 Model „home" for AI unicorns W1T2 Development model AI as environment W2T2 Cooperative AI clusters W3T2 Increasing AI skills of workforce. Promotion of AI technologies to society W4T2 Model „home" for AI unicorns W1T3 Investments in emerging technologies W2T3 Forming large public AI firms W3T3 Diversification AI products and services W4T3 Diffusion AI technologies at industry W1T4 Development AI ethics regulation based on EU AI regulatory framework W2T4 Organize consultations with AI companies about AI ethics regulation W3T4 Development AI ethics regulation W4T4 Development AI ethics regulation

Source: compiled by the authors

Table 4 – Directions of Ukraine's Artificial Intelligence Technologies' Implementation

	O 1. Using AI technologies in manufacturing 2. Development of AI startups funding programs 3. Digital country's development 4. Focus on leveraging AI to serve people and business	T 1. Intellectual AI property rights belong to foreign companies. 2. Small number of AI startups 3. AI startup's products mostly are not used at internal market 4. Weak statistical data collection system
S 1. Regulatory framework for AI 2. High infrastructure level 3. High level of physics and math school education 4. Market AI solutions	S1O1 Diffusion AI technologies at industry S2O1 Development BTB AI applications S3O1 Development cooperation between manufacturing enterprises and schools in AI education and invention S4O1 Cooperation between manufacturing and AI companies S1O2 Model „home" for AI unicorns S2O2 Investments in emerging technologies S3O2 Creating AI courses for schools S4O2 Forming large public AI firms S1O3 Investments in emerging technologies S2O3 Development BTG AI applications S3O3 Increasing AI skills of scholars S4O3 Cooperative AI clusters S1O4 Diversification AI products and services S2O4 Development model AI as environment S3O4 Development AI-assistants for schools and scholars S4O4 Diversification AI products and services	S1T1 Development national AI tools of supplies S2T1 Forming large public AI firms S3T1 Adding Intellectual AI property rights information as part of school subjects S4T1 Development internal market of AI applications S1T2 Forming AI skills of workforce S2T2 Development model AI as environment S3T2 Computer software spending for schools S4T2 Development internal market of AI applications S1T3 Promotion of AI technologies to society S2T3 Diversification AI products and services S3T3 Development AI-assistants for schools and scholars S4T3 Development model AI as a service. Forming large public AI firms S1T4 Development ethics regulatory framework for AI S2T4 Development ethics regulatory framework for AI S3T4 Adding Intellectual AI property rights information as part of school subjects S4T4 Development AI ethics regulation
W 1. Have similar AI policy goals with the European Union's approach, but are more nationally self-reliant 2. Locations 90 % of AI companies in Kyiv, Dnipro, Kharkiv, Lviv regions. 3. Low level of society readiness to use AI 4. Small number of registered AI patents	W1O1 Making standards for AI products and services that use for export W2O1 Development model AI as environment W3O1 Increasing AI skills of workforce. Promotion of AI technologies to society W4O1 Forming large public AI firms W1O2 Development model AI as service W2O2 Development internal market of AI application through development BTG applications W3O2 Development BTC AI applications W4O2 Development model AI as environment W1O3 Building common Program initiatives with EU at AI startups development W2O3 Computer software spending in regions W3O3 Computer software spending in regions. Promotion of AI technologies to society W4O3 Model „home" for AI unicorns W1O4 Focus on BTC and BTB applications W2O4 Forming large public AI firms W3O4 Promotion of AI technologies to society. Development BTC and BTG AI applications W4O4 Diversification AI products and services	W1T1 Forming large public AI firms W2T1 Forming large public AI firms W3T1 Increasing AI skills of workforce. Promotion of AI technologies to society W4T1 Model „home" for AI unicorns W1T2 Building common Program initiatives with EU at AI development W2T2 Cooperative AI clusters W3T2 Increasing AI skills of workforce. Promotion of AI technologies to society W4T2 Model „home" for AI unicorns W1T3 Development internal market of AI application through development BTG applications W2T3 Investments in emerging technologies. Forming large public AI firms W3T3 Promotion of AI technologies to society. Development BTC and BTG AI applications W4T3 Promotion of AI technologies to society. Development BTC and BTG AI applications W1T4 Development AI ethics regulation W2T4 Organize consultations with AI companies about AI ethics regulation W3T4 Development AI ethics regulation W4T4 Development AI ethics regulation

Source: compiled by the authors

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