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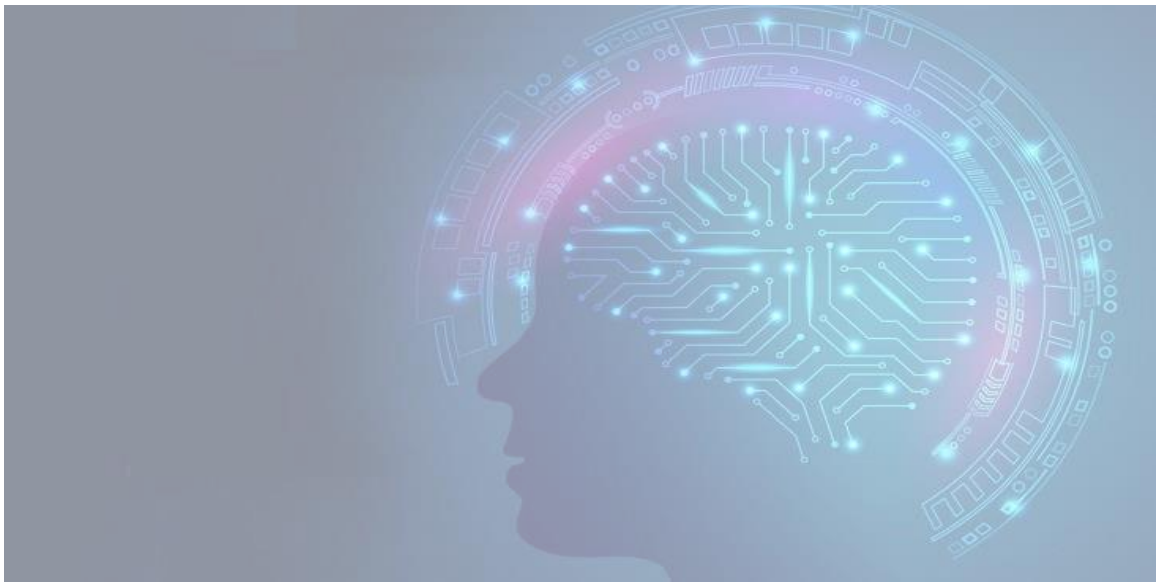
GOOD PRACTICES OF INDUSTRY 4.0 IN UKRAINE

Mariia Golovianko, Svitlana Gryshko, Lyudmila Tytova, Valentyn Filatov



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Introduction

This research was performed within Erasmus+ JoInME Project "JoInt Multidisciplinary training program on Entrepreneurship in the field of artificial intelligence for industry 5.0".

The main goal of the JoInME project is to offer an up-to-date joint intercultural and multidisciplinary training program on entrepreneurship in the field of AI for Industry 5.0.

There are already examples and good practices of using AI and developing Industry 5.0 all over Europe. This desk research is made by the team from Kharkiv National University of Radio Electronics to identify the winning practices from Ukrainian startups or companies working in the Industry 4.0/5.0 and using AI. They can be an inspiration for teachers as well as students.

I. The current trends and state of Industry 4.0./5.0

A. The national context of Industry 4.0/5.0

What are the current trends regarding Industry 4.0/5.0 in your country? Is it a well spread trend? Does your government encourages the shift in technologies? Is there any national strategy to increase the companies' innovativeness towards Industry 4.0/5.0? How is the willingness of local companies to shift to Industry 4.0/5.0?

Systemic work on the Industry 4.0 strategy creation and implementation in Ukraine has begun after the launch of the pro-governmental program Digital Agenda for Ukraine in autumn 2016. A special section of the program was reserved for numerous initiatives emerging in Ukraine to force the development of Industry 4.0.

The National strategy for Industry 4.0[1] appeared in Ukraine in December 2018 initiated by the Association of Industrial Automation of Ukraine (APPAU). APPAU is the key body engaged in the development of Industry 4.0 uniting more than 50 (as of 2022) top Ukrainian industrial actors, among them industrial vendors (manufacturers – suppliers of equipment and software in the industrial automation system), HEIs, research centers, system integrators, OEMs, IT developers, engineering companies, and industrial enterprises. Since 2016, the Association of

[1] https://appau.org.ua/en/pubs/national-strategy-4-0/

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Industrial Automation of Ukraine (APPAU) has implemented more than 10 projects of different scale and area, such as, the development of strategies and individual provisions of Industry 4.0 and industrial development, development of Centers 4.0, standardization, cluster development, smart specialization, improving international cooperation and more.

Together with the partners (the Council of Entrepreneurs at the Cabinet of Ministers, the Institute for Economic Research and Policy Consulting, the Chamber of Commerce and Industry of Ukraine, the Office of Reforms at the Cabinet of Ministers of Ukraine, the European Innovation Agency, and the Ukrpromzovnesheksрertiza), APPAU founded National movement Industry4Ukraine (https://land4developers.com/). The mission of the movement is to develop industrial hi-tech segments in Ukraine to make Ukrainian economy stronger and in line with Industry 4.0 trends. By the 2022 the movement incudes more than 200 members coming mainly from IT and Industrial Control System markets.

The National Strategy includes 13 projects and a set of tasks of policy synchronization with the Government (see Fig.1).

Fig.1 – 13 projects of the National Strategy 4.0 divided into 5 directions

Main objectives of the Strategy are:

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- growth of manufacturing 10% per year that gives growth in GDP from 12% (2017) to 20 % (2022).
- Faster growth of industrial engineering sectors, 10- 20% per year.
- Capital attraction into local 4.0 capacities: production, Center R&D, incubators and SMBs.

In order to achieve those development had to move in thee following directions in 2019-22:

- synchronization with Industrial and Innovation Strategies at the State level.
- Creation of innovative ecosystem for industrial engineering sectors.
- Speed-up of clustersation processes in 4.0 at regional as well at the national levels.
- Full-scale digitization of key sectors in manufacturing, energy and Utilities sectors.
- Integration of technologies 4.0 into Defense strategies.
- Launch of export programs for industrial engineering.
- Integration into EU and WW environment of 4.0.

In 2018-2019 Industry4Ukraine established a network of Industrial Centers 4.0 (research hubs based on universities and science parks), developed roadmaps for digital transformation of the state railway system and the food industry, aligned Ukrainian standards with the EU regulations, and held several important surveys.

In 2018 the concept of innovation clusters EAM (Engineering - Automation - Mechanical Engineering) was introduced as a mechanism for boosting innovation potential of Industrial high-tech sectors. Thus, the National Cluster Development Program officially started in 2020. Clusters` mission is to encourage innovation and enhance collaboration of various important players in the sectors of engineering, automation and machinery in 5 regions of Ukraine.

The first attempts to determine how the Ukrainian landscape of innovators 4.0 looks like were made in 2018 and the first raw image of the Industry 4.0 landscape in 2017 was obtained (see Fig.2). It comprised around 65 manufacturers offering services and products 4.0 in Ukraine[2]. There are almost 50 Ukrainian brands among them, the other 15 are Western well-known brands, suppliers of equipment and software, which are present in Ukraine.

[2] https://land4developers.com/2020/05/01/the-landscape-industry-4-0-in-ukraine/

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Fig.2 – Version 1.0 of the Ukrainian Industry 4.0 landscape (2017)

Though various organizations and companies of Ukraine mostly support the necessity of applying the approaches of Industry 4.0 (more than 79% as for 2019) (Nikitin et. al., 2019), still very few really use them. For instance, in regards with the assets performance management according to the report by the Ukrainian experts from APPAU it is still no more than 1% of companies which systematically applied 4.0 technologies in 2021 (Fig.3). The overwhelming majority of enterprises are still located at 1.0-2.0 levels: data capture, integration, visualization and analytics are still not widely used to improve the reliability and availability of physical assets.

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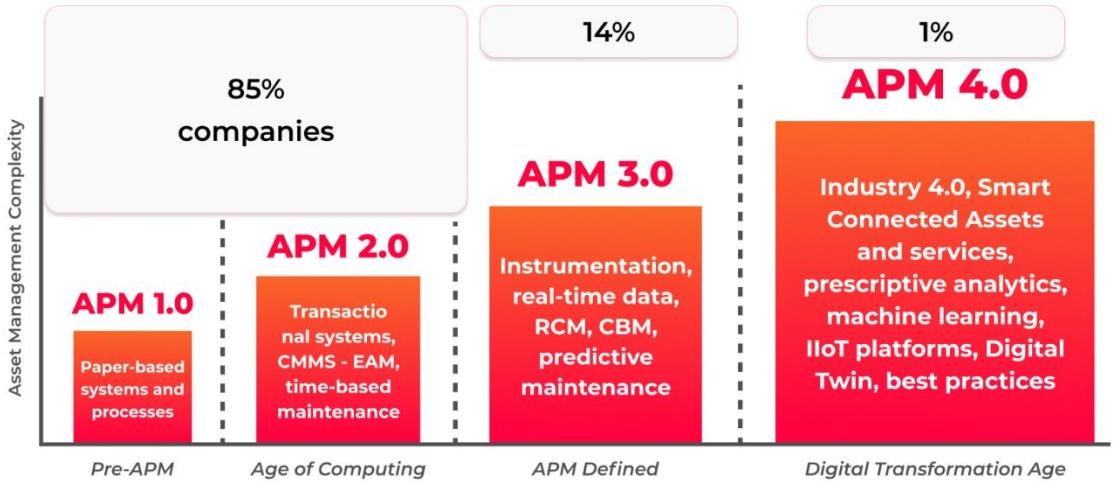

Fig.3 – Technological development of Ukrainian companies in regards with the assets performance management

Among strong integrators and developers who are already performing 4.0 assets management are **IT-Enterprise** (https://it-enterprise.com/), **Waites** (https://waites.net/), **Indusoft** (https://indusoft.com.ua/), **a-Gnostic** (https://a-gnostics.com/).

In 2019 version 2.0 of the Ukrainian Industry 4.0 Landscape was prepared, this time the emphasis was on companies of Ukrainian origin. The use of 4.0 technologies for Industry 4.0 was the main criterion for filtering existing innovators. This version of the Landscape included around 80 local innovators spreading through 16 technology sub-segments (see Fig.4).

Companies in AI / Big data segment are dominant, but other segments, such as, Additive manufacturing and Industrial Internet of things (IIoT), are also showing the fast growth. The second place is given for the segment of IoT-devices (27 companies), the third place – AR / VR (11 companies). Companies developing 3D and cyber-security are also present.

This Landscape 4.0 shows the strong potential of Industry 4.0 in Ukraine, considering that real number of Industry 4.0 companies should be multiplied at least by 2. 70% of the companies of the Landscape work in Ukraine; 50% are product companies, 20% are system integrators and just 30% company work for abroad customers according to the outsourcing model.

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Fig. 4 – Version 2.0 of the Ukrainian Industry 4.0 landscape (2019)

According to Alexandre Yurchak, CEO of APPAU and the coordinator of the Industry4Ukraine platform, in 2022 it is already more than 100 innovators with competitive products and solutions in Advanced manufacturing that are shaping Industry 4.0 Landscape in Ukraine (Yurchak, 2022). Among them[3]:

- Infocom Ltd (https://ia.ua) is a Ukrainian developer in the UGV (unmanned Ground Vehicle) segment. They create unmanned vehicles, robotic

[3] https://land4developers.com/2020/05/01/best-examples-of-innovators-4-0-in-ukraine/

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platforms for security, fire and military purposes, other military unmanned aerial vehicles, high-tech products for solar energy and for electric transport infrastructure.
- Smart Factory (https://www.softelegance.com/) is a Ukrainian MES/APS development that is required by industrial enterprises as they go to the integration of manufacturing lines and machines in workshops. IT-Enterprise also has a number of other advanced products and is increasingly featured in the Landscape 4.0.
- Molfar Technology (https://molfar.tech/) is a young firm that has develops AI / Drones / Machine vision solutions.
- Drone.ua (https://drone.ua) is a well-know drones manufacturer with applications in Agro-industry, but also in Energy and Infrastructure.
- SoftEngi (https://softengi.com/) create digital twins with the extensive use of XR technology.

Sectors which generate today the biggest part of GDP are Food, Metallurgy, and Energy, while potential drivers of economic development are Engineering, Aerospace, Defense, Biopharma, and Machinery).

In recent years, Ukraine has developed a reputation as an international information technology (IT) hub. The IT Association in Ukraine reported around 116.000 software engineers working in the market in 2018, and more than 250.000 at the beginning of 2022. While there is still a lack of data scientists, DevOps engineers, Machine Learning engineers and other AI experts, they are, often, much easier to find and hire in Ukraine than in Western Europe, and their number is keep growing.

Ukraine has a rich history when it comes to scientific innovation, from physics to life sciences, education, alternative energy, chemistry and engineering. According to Gali Halevi, Director at the Institute for Scientific Information, the country makes significant contributions to the global scientific effort, not in the least due to the tremendous growth in domestic and foreign investments in research and development (Halevi G., 2022).

Such investment has enabled the development of the infrastructure needed for sustainable, efficient technologies and processes before the Russian invasion of Ukraine in 2022. With over 2000 startups, Ukraine had also a fast-developing startup ecosystem. Ukraine was in the top 30 startup countries globally according to Startup Ecosystem Rankings 2020 by StartupBlink which ranks the startup ecosystems of 100 countries and 1000 cities (Ukrainet, 2020). Kyiv, the capital, made it to a respectable 32nd place globally and 8th place in Europe. The startups that were founded by Ukrainians include some world-known ones, such as, for

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example, Grammarly (https://www.grammarly.com/) and Looksery (http://www.looksery.com/).

Now due to the Russian aggression Ukraine shows a negative momentum in the startup ecosystem (StartupBlink, 2022). However, according to the Ukrainian government's assessments, more than 70% of Ukrainian start-ups are continuing to operate despite the war. In order to help businesses continue operations and move closer to the EU tech sector the European Innovation Council (EIC) has set up €20 million fund for Ukrainian start-ups. They believe Ukraine has a vibrant deep tech community and strong potential for creating breakthrough innovations which can become a key economic driver for rebuilding the Ukrainian economy and infrastructure after the war (Naujokaitytė G., 2022).

B. The effect of COVID19 on national companies in terms of shifting to Industry 4.0/5.0.

Does the pandemic changed anything in this transition process? How does it influence companies on their strategies and operations in general? What are the major setback or advantages that companies got from the pandemic?

Ukraine had been undergoing an historical digital transformation before the upheavals of 2020.

In 2018 the government set a five-year digitization course in the "National Industry Strategy 4.0", according to which the key factors of the development were selected: consolidation of major 4.0 stakeholders and government agencies, active involvement of the IT sector in the transfer of experience of globalization and best business practices enterprises, creation of an innovative ecosystem of industrial high-tech segments, integration into European and world chains values, accelerated development of industrial segments in Ukraine ().

In September 2019, Ukraine established the Ministry of Digital Transformation based on its predecessor state agency aimed at the creation of the e-government – "the state in the smartphone" which had to improve public administration and service delivery in Ukraine by 2024, increasing the performance and efficiency of state institutions, and reducing opportunities for administrative corruption due to digitization and virtualization of various processes. Since then, Ukraine has become the first country in the world to introduce e-passports, the fourth European nation to offer digital driver's licenses. It boosted the world`s fastest online business registration process via the governmental Diia portal and correspondent mobile services. Ukraine has also leaded the world in the number of online public services for children and newborn via the eMalyatko platform.

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In 2019, the government launched the National Startup Fund of Ukraine (USF) endowed with USD 20m of available funding, a public initiative to support innovative projects. The fund's resources amounted to about $ 14 million to distribute grants from $25,000 to $75,000 among promising Ukrainian startups and up to $10,000 grants for acceleration programmes. Originally set up to promote the development of the local startup ecosystem and internationalisation, USF today is the largest local angel investor with over 100 funded startups and the most extensive database for startups and stakeholders (over 3,000 applications).

In the United Nation's 2020 e-Government Survey, released on July 10, Ukraine placed 69th in the world, with an E-Governance Develop Index, or EGDI, of 0.7119, which is a big leap from the rank 82 with an EGDI of 0.6165 two years before ().

High-profile founders like WhatsApp's Jan Koum, Revolut Ltd.'s Vlad Yatsenko and the country's roughly 250,000 technology professionals gave Ukraine an outsized reputation among coders, with tech workers clustered in offices in Kyiv and other hubs around the country.

The COVID-19 pandemic and quarantine restrictions nudged Ukraine towards even more rapid digital transformation (Bogoyavlenska et al., 2021).

Accelerated digitization due to COVID

Boost of digital innovations in the private business and public sectors in Ukraine was essentially facilitated by governmental initiatives aimed at tackling the outbreak of the COVID-19 disease in Ukraine and making life easier for citizens and businesses:

- a series of new governmentally promoted mobile applications and services was introduced for Ukrainian citizens, a.o., mobile application Vdoma enabling convenient self-isolation monitoring (Fedorov M., 2021).
- A national competition #HackCorona was launched by the Ministry of Digital Transformation, in partnership with the United Nations Development Programme in Ukraine, to find new IT projects and innovative ideas that could fight the pandemic.
- A national programme for the development of a system for comprehensive support of ICT innovation and digitalisation of SMEs, providing access to knowledge, markets, infrastructure and sources of funding through a network of 24 EU|BICs (Certified Business Innovation Centres) was included into the Government Priority Action Plan of Economic Recovery 2020-2022 (Denys Shmyhal, 2020).

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- The National Startup Fund of Ukraine started looking for new innovative projects to fight the pandemic and its consequences.
- A concept of Diia City (Digital Country), a new legal framework for IT industry developed by the Ministry of Digital Transformation of Ukraine. The aim is to create a virtual country with virtual services for IT sphere and a place for unlimited investments.

The increased demand for more flexible business and social processes maximized the need for non-trivial solutions and “think out of the box” ingenuity. Businesses have been forced to adopt new internal working practices and routines and felt a strong pressure to emphasize online remote work (Gryvnyak, 2020), moreover, they have started offering their products or services through various digital channels.

Demand for the social impact of the transition process

An important consequence of the pandemics was the newly acquired understanding that the world requires not only effective digitally enabled solutions, but a much higher level of process resilience, production sustainability, and decision-making quality (European Commission, 2021). The human role in digital transition was thoroughly reconsidered: social impact of the innovations has become a key factor for their success and wide adoption. This explains the growing popularity of the Industry 5.0 concept, which (unlike Industry 4.0) is supposed to bring humans back into the loop of the industrial processes, and citizen-oriented digitalization products.

Cybersecurity as a priority

It became clearer that the solutions developed or supported by various initiatives, pilots and technical assistance projects should be compatible, secure and adequately certified for personal and sensitive data protection.

The main lessons learnt

COVID-19 outbreak helped revealing two big problems of the Ukrainian digital transformation:

- impaired digital literacy. It has become apparent that there is a need to enhance citizens` digital skills and abilities. According to a nationwide study on digital literacy (Ministry of Digital Transformation of Ukraine, 2019), some 38 percent of Ukrainians have digital literacy skills lower than average, while 15 percent of the population may be dubbed digitally illiterate. Throughout 2019, 34 percent of the Ukrainian citizens aged 18-70 became victims of internet scams, and only 14 percent know how to protect their data online.

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- digitalization without proper attention to filling the digital divides between citizen groups (defined by sex, age, skills, disabilities and economic status), while eliminating old inequalities, has the potential to cause new ones – especially in middle-income countries such as Ukraine (Gercheva, 2020; Fouani, 2021).

To address these problems, the national program for promoting digital literacy: “Diia. Digital Education” was launched during the pandemic. The “Diia. Digital Education” platform was created in the form of edutainment, where free series are combined with experts and celebrities to explain how to use websites, the possible applications of smartphones and laptops, basic Internet safety rules, use of online services and courses on how to find jobs and how to acquire new skills to combat rising unemployment. The audience on the platform rose from 36,000 people to 200,000 (in June 2020) (Gryvnyak, 2020).

II. Resilience of business processes during and after COVID19

A. Main strategic and operational challenges of companies and startups

Please provide some examples on how the pandemic affected the operational and strategic decision making in companies’ life. What were the biggest challenges that companies needed to face during and after the pandemic? How did it influence their transition into Industry 4.0./5.0?

During the period from the 20th April to the 8th May 2020, the Resource Efficient and Cleaner Production Centre (RECPC) carried out a special survey in the industrial sector aiming to search for answers to how COVID-19 had affected manufacturing enterprises in Ukraine and what needs and challenges it had triggered (Vorfolomeiev, 2020). Total 58% of companies reported significant changes in operation caused by COVID-19. They declared that the industrial sector had been strongly affected by (i) the need to close or stop industrial facilities due to governmental regulations, (ii) the reduced economic activity, the decreased demand for raw materials produced and exported by Ukraine, and (ii) disruptions in logistics and transportation. It led to lower prices of Ukrainian products on world commodity markets and reduced investment due to significant uncertainty (Lebedeva et al., 2021). The findings showed that the coronavirus crisis hit the industrial sectors mainly in April 2020, leading to a 16.1% decline in industrial

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production in Ukraine and an 18.6% decline in the EU. Such industries as automobile manufacturing, light industry, furniture manufacturing, coal mining, oil and gas extraction were hit the hardest. The decline in production, the closure of markets and borders, the cancellation of orders led also to serious logistical problems in the agricultural sector, one of the two main sources of foreign exchange earnings in the country (up to 40%) due to agricultural export. Insurance industry also experienced an acceleration of the digital transformation.

By June 2020 29% of Ukrainian companies have stopped functioning and 6% have fully closed down their businesses. More than 277,000 private entrepreneurs/ small businesses have closed down due to the quarantine.

The new normal required business leaders to react extremely quickly and think critically due to fast changes in the business environment. They found themselves in the situation when the existing business models didn`t work, thus they had to be essentially changed and new working formats had to be established (Gryvnyak, 2020). Many of the businesses in Ukraine reported the need to modify their operational and strategic decision making, in particular, to introduce new digital technologies and tools.

Experience of Ukrainian companies confirms the overall conclusion that digitally native organizations that were “insight-driven by default” showed much higher resilience, allowing them to manage the crisis more smoothly, and were able to tighten their dominant market positions, even growing share value while stock markets tumble (Bakker et al., 2021). E.g., Vodafone Ukraine, working in telecom industry, that had initiated digital transformation of their business before COVID outbreak, adapted their business processes to the new realities more quickly than other companies, since it was easier for them to switch to out-of-office work (Ustinova, 2020). Even such conservative industries, as the insurance industry, provides similar cases: insurers that were well advanced with digital transformation responded to the pandemic with greater speed and agility than their more cautious competitors. Thus, even during the “quarantine” first half of 2020, the life insurance sector grew by 10% and the market leader MetLife was largely a growth driver: as in the previous pre-crisis year, its premiums grew by 24% (Shevchuk, 2020).

COVID-19 also opened new opportunities for some important industrial sectors (e.g., the agricultural sector): accelerating and expanding the process of digitalization, and giving new opportunities for the expansion of the market. Until 2020, agriculture focused on digitalization of production processes by use of robotics, drones and satellites, artificial intelligence, the Internet of Things. However, during the pandemic, the digitalization of the sales process became an urgent issue, since traditional access to the consumers was problematic due to the

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closed markets. Management was actively digitalized during the pandemic. (Kaminskyi, 2021).

B. National best practices on how to tackle challenges that came with the pandemic

Please, provide some examples on how well (or badly) companies responded to these challenges. What were the major changes that companies needed to apply to stay competitive during these times? Also, if you know any specific trends in industry that has arisen because of the pandemic, include it in this section.

The pandemic had a huge immediate impact on everyday approaches to everything – from school education, household chore division or the social life to the way people dealt with banks, paid bills or interacted with the health system. It made people think faster and seek new solutions, oftentimes of a digital nature.

Highlighting cyber-consciousness and social responsibility

Health and lives of employees are the priority for all businesses and organizations. Combating the pandemic extends beyond medical and clinical approaches: corporate social responsibility or, in other words, shared responsibility of companies for societal well-being, is believed to be an effective tool available for many stakeholders, including enterprises (García-Sánchez et al., 2020).

Understanding the importance of the (i) monitoring of the coronavirus spread; (ii) research and development of diagnostics, treatments and vaccines, (iii) wide outreach of the important and truthful information about the virus and willing to give back to society, Ukrainian IT companies actively contributed to the development of modern digital tools automating these processes.

SoftServe (https://www.softserveinc.com), a technology company specializing in consultancy services and software development, for instance, developed e-tools:

- the STOP COVID-19 online platform and chatbots providing the latest information about the pandemic in Ukraine;
- FightCovid19, to help systematizing the actual demands of hospitals linking them to relevant donors and investors.

Cyber-consciousness has become another important component of the corporate culture in COVID times. Businesses needed to adapt to the new practices to increase profits, so they increased their usage of e-signatures, online tools for business operations, online consulting and ordering and digital payment systems. Therefore, they also needed to increase the working capabilities of employees by

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digital retraining and upskilling, supporting them in exploration of new digital tools and social media:

- SoftServe took part in the development and sharing of technological expertise at various levels: regional and national. They offered educational services for local institutions, state authorities and public bodies.
- The pandemic was the main reason for Ferrexpo Poltava Mining (https://www.ferrexpo.com/), the world's third largest exporter of iron ore pellets, to launch a virtual reality simulator "Ferrexpo Digital Training", a unique cross-platform complex solution based on VR / AR technologies. The need to train their employee dismantling various piece of equipment was as high as always, but COVID-times required new non-traditional innovative solutions.

Moving businesses online

Industries fast-tracked their adoption of Industry 4.0./5.0 technologies. Many of them, such as, the automotive industry, started moving online more rapidly (Analytical Center Industry4Ukraine, 2020):

- ŠKODA dealers in Ukraine were starting to implement a new dealership concept in the context of Industry 4.0, simplifying the process of buying a car and making it user-friendly[4].
- Entrepreneurs in the food industry either started to change business models and work with deliveries or started new projects in the production. Both versions relied on modern digital tools and online services. Online food delivery services became a booming sector (Antoniuk, 2020).

Engaging informed decision-making with help of AI and Industry 4.0-ready systems

Managerial decision-making processes also transformed radically. Industry 4.0-ready systems were taken aboard of enterprise resource planning (ERP) to manage all aspects of a production-based or distribution business, aligning financial management, human resources, supply chain management, and manufacturing or distribution with the core function of accounting:

- the pandemic forced big Ukrainian grain trader MGrain (https://www.m-grain.com/) to deploy SAP S/4HANA Cloud system for enterprise resource planning (ERP) to effectively manage their day-to-day business activities such as accounting, procurement, project management, risk management and compliance, and supply chain operations[5].

[4] https://www.skoda-auto.ua/owners/buy-online
[5] https://www.sap.com/ukraine/about/customer-stories.html

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- The New Products Group of Companies (https://newproducts.com/), the leader in the Ukrainian snack and beverage market, joined the trend of digital transformation in 2020 and reported a new level of cooperation with distributors and customers with the use of Secondary Sales control system by SAP Business One which ensures accurate forecasts and helps them serve more than 25,000 customers and 106,000 active outlets worldwide[6].
- The leader of the pharmaceutical market of Ukraine with a share of 6% and the largest exporter of medical products Farmak (https://farmak.ua) was the first among Ukrainian pharmaceutical companies to implement the SAP SuccessFactors system to automate the most important and time-consuming HR-processes in the field of personnel management[7].
- To fight against COVID-challenges KERNEL (https://www.kernel.ua/) created a virtual version of its decision making and operational infrastructure. KERNEL is the world's leading and Ukraine's largest producer and exporter of sunflower oil, a major supplier of agricultural products from the Black Sea region to international markets. It is a vertically integrated company with more than 30 legal entities located throughout Ukraine and about 12.7 thousand of staff. Non-standard digital tools were developed and introduced to provide the employees, a.o., managers, with information for business decisions in any geographical location, and would allow to implement HR processes, get all the necessary services and access to reporting, and at the same time would allow them to sign and agree on all documents related to business activities: contracts, orders, primary financial documents from a smartphone to address the challenges of the pandemic.
- Myronivsky Hliboproduct (https://mhp.com.ua), Ukraine's largest agricultural produce company with over 50% of the country's "industrially produced poultry", started digital transformation in 2020, integrating and synchronizing all internal processes related to enterprise resource planning, customer experience, purchasing, HR, and others.
- Some enterprises declare that initiated due to COVID-19 digital transformation has increased their investment attractiveness, improved the transparency and reliability of the company's reporting, accelerated the collection of information, and minimized errors due to the human factor. One of them is Naftogaz Group (www.naftogaz.com), the largest state-owned company in Ukraine implementing a full cycle of field exploration and development, production and exploration drilling, storage of oil and gas,

[6] https://www.sap.com/ukraine/about/customer-stories.html?sort=latest_desc&video=e27823de-ca7d-0010-87a3-c30de2ffd8ff
[7] https://interfax.com.ua/news/economic/765369.html

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processing and distribution of oil products, natural gas and liquefied gas to consumers. To become more flexible and efficient in times of global crisis Naftogaz started running the intelligent systems for procurement of materials and services, payments to contractors, shipment of products, accounting transactions, handling of tax invoices and declarations, monitoring the implementation of budget limits[8]. For employees, the focus has shifted from routine data collection and aggregation tasks to analytical tasks. Automated processes and technologies allowed to move the enterprise towards a virtual organization.

- Businesses started actively using AI-based digital platforms, for example, Vanongo platform (https://vanongo.com) that connects business and individuals with a network of drivers for smart deliveries.

Increasing supply chain resilience

Emerging technologies, including the Internet of Things, big data, cloud computing, additive manufacturing, and blockchain started being used more actively to streamline supply chain resilience in Ukraine, increase their robustness during an emergency or an unexpected and dynamic catastrophe, provoked by the pandemics.

- Farmak company was forced to implement a fast introduction of Industry 4.0 solutions for supply chain management - an Integrated Business Planning (IBP) system, a cloud-based planning software that uses real-time information to help companies respond more quickly to market and business volatility, as well as to manage the supply chain disruptions caused by the COVID-19 pandemic.

Moving towards smart production

The unique advantages of smart manufacturing and smart agriculture production in automating the factory floor and incorporating new services into all kinds of products is a great advantage in the times of extreme vulnerability of human employees.

- Kernel deployed a single innovative ecosystem of modern agricultural production DigitalAgriBusiness. By February 24th, 2022, 100% of the fields were covered with quality RTK signals, the basis for precision farming. 100% of the company's fields were monitored using satellite images, copters, as well as IT tools that agronomists work with directly in the fields. The data of this monitoring was automatically stored in the database and

[8] https://www.sap.com/assetdetail/2021/04/3c2a699b-da7d-0010-87a3-c30de2ffd8ff.html

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became the basis for efficient and timely decision making and visualization using an analytical GIS portal, containing all the information about the processes taking place in the fields.

- Myronivsky Hliboproduct launched Virtual Zootechnician project for building smart production based on automated processes[9]. They constructed a management system for all processes of poultry farming, including the collection of data on equipment and the automatic selection of optimal microclimate modes with the use of drones for autonomous monitoring of the production processes.
- MAS Seeds Ukraine, a Ukrainian subsidiary of the French seed company MAS Seeds, which is the part of the agricultural cooperative group MAISADOUR, started using data science for selecting better quality seeds.

Emergence and development of new markets

Spurred significantly by the coronavirus Ukraine started massive transformation and development in the spheres of e-governance and e-health, where the use of digital health apps and software is becoming a daily practice, e.g. governmental related app DII VDOMA for monitoring person's self-isolation status.

Some new digital markets, such as Telemedicine, have grown and developed significantly due to the pandemic and the emergence of new medical 4.0 technology. COVID-19 has overwhelmed the capacity of health care systems, limiting access to traditional services. Telemedicine has emerged as a tool to provide care continuity to patients while limiting the risk of contagion (Hojouj, 2021).

Developing digital infrastructures for Industry 4.0

Mobile companies accelerated the development of the 4G infrastructure, connecting new settlements to the network.

III. Implementing AI solutions at national companies

[9] https://api.next.mhp.com.ua/images/ad6f4/7693c/639e37d2.pdf

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A. Interest and openness towards AI at national companies and startups

In the general context from your country, are companies and startups open to AI solutions? How much are they willing to integrate AI solutions in their operational and strategic processes? Are they willing to implement or rather reject the idea of using AI technologies? What is the reasoning behind the decision of either implementation or rejection?

As of beginning of 2022, IT market in Ukraine experienced a significant growth over the last 10 years, with the most active dynamics during the last 5 years. Ukraine had demonstrated the growth rate of the IT services market at 20-25% annually (Invest in Ukraine, 2022). IT sector accounted to almost 300,000 technicians in software development and maintenance services. It topped the list of service exporters (over $ 5 billion per year) and generated more than 4% of Ukraine's GDP (IT Ukraine Association, 2022).

What is important, Ukrainian tech sectors experience qualitative transformations: increasing number of companies start to develop own products distancing from outsourcing model prevailing in Ukraine for years. The share of the companies engaged in the development of AI solutions has significantly grown.

Artificial Intelligence is one of the fastest-growing areas of expertise. The overall expertise varies from ML to robotics and recommendation systems. Machine learning in Ukraine accounts for more than a quarter of projects that Ukrainian companies work with (see Fig.5). Another aspect of the artificial intelligence in Ukraine of IoT, with almost the same number of projects.

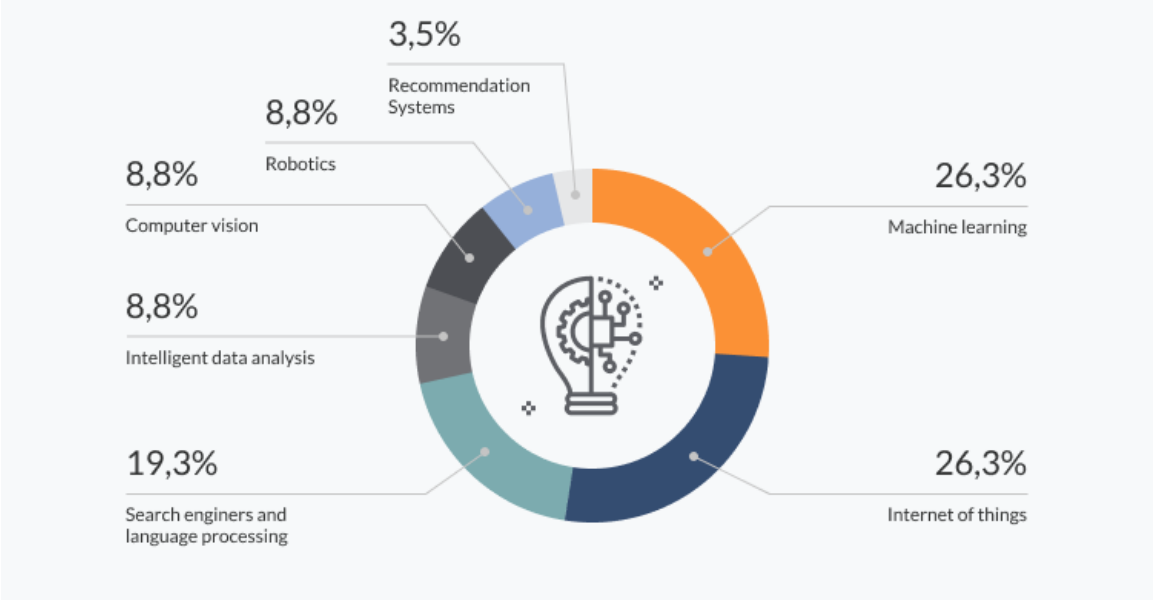

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Fig. 5 – Industry and technology distribution in Ukraine (source: www.n-ix.com)

Ukraine has become the significant player in the AI market in Eastern Europe. In 2018, according to Clutch, the leading rating and reviews platform for IT, Marketing and Business service providers, Ukraine was among the top three countries in Eastern Europe by the number of companies in the field of Artificial Intelligence. And already in 2020 it hit the first place of the ranking. According to the 2020 Oxford Government AI Readiness Index (Shearer et al., 2021), Ukraine was the number one artificial intelligence provider in Eastern Europe with almost 150 recognized providers compared to Poland's 110[10]. They mark an important increase in the AI expertise in Ukraine: in just 3 years, the number of AI-related companies has gone up 4 times.

In their analysis of an AI ecosystem in Ukraine[11], Deep Knowledge Analytics, a leading Deep Tech analytical agency, observe 450 attractive to domestic and foreign investors AI-related companies operating in Ukraine as of beginning of 2022 (Deep Knowledge Analytics, 2022). They declare that the Software Development industry takes the biggest share of 33.8% of AI companies operational market (see Fig. 6), with respect to the business operations conducted by them.

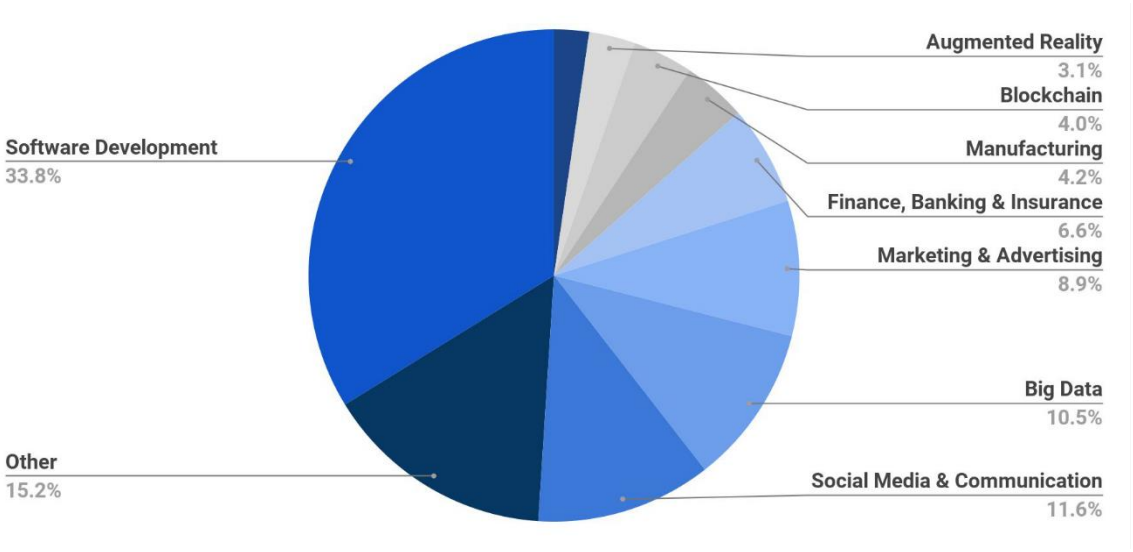

Fig. 6 – Distribution of industries on the Market of 450 AI Companies

[10] https://www.atlanticcouncil.org/blogs/ukrainealert/ukraines-roadmap-to-an-artificial-intelligence-future
[11] https://analytics.dkv.global/Ukraine/mindmap-AI-in-Ukraine.pdf

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Companies already implementing AI technologies are primarily the ones that are engaged in software development of various kinds, a.o., for internal usage and selling their software as a service. Among 450 companies in the list there are 81% of those. And about one-third of companies work in such industries as social media and communication, marketing and advertising, and Big Data (Fig. 7). 70% of Ukrainian AI companies are located in Ukraine, however, 16% operate in United States and more than 3% of the companies are oriented to the UK market.

Billion-dollar Ukrainian startups including Grammarly (https://www.grammarly.com/) and GitLab (https://github.com/) have managed to establish a global presence while maintaining AI offices in Ukraine.

Due to the potential of the Artificial intelligence (AI) industry, investments in Ukrainian companies applying AI increased significantly over the last 10 years from $42.4 million in 2014 to $440.9 million in 2021 (see Fig.8) (Deep Knowledge Analytics, 2022). Global tech giants such as Samsung, Google, and Rakuten have established AI R&D centers in the country. The decline in investment happened in 2020 due to COVID-19, and in 2022 ($1.1 million in Q1 2022) due to the war of russia against Ukraine. Due to the war, 41% of Ukrainian startups reported the lack of money but 72% will try to continue operating[12].

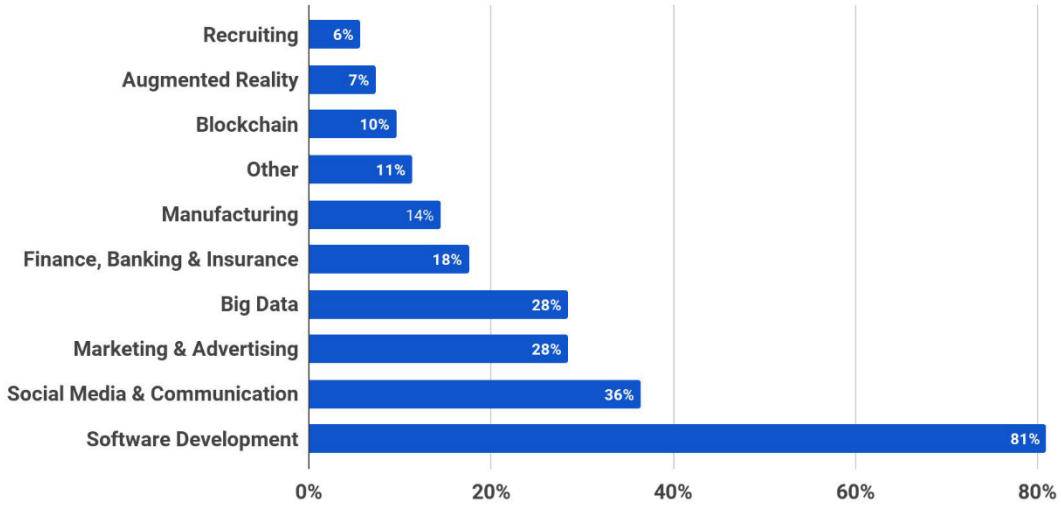

Fig.7 – Industry vectors among 450 companies

[12] https://usf.com.ua/startup-voice-rezultati-opituvannya-startap-ekosistemi-ukraini/

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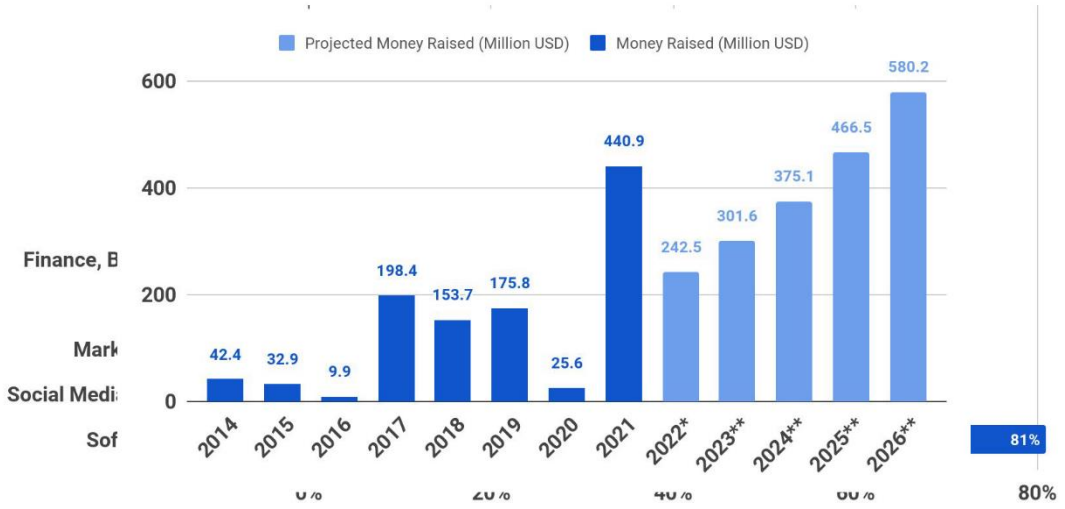

Fig.8 – Investments in Ukrainian companies applying AI

Many experts believe the vibrancy and dynamism of Ukraine's AI industry are at least partially due to the relative absence of government interference in the sector and the established free market (Goncharuk, 2021). Before 2020 AI industry had no significant state support. That can be confirmed by the Government AI Readiness Index rating which assesses the readiness of governments to implement artificial intelligence. The overall score is comprised of 11 input metrics, grouped under four high-level clusters: governance; infrastructure and data; skills and education; and government and public services.

In 2019, Ukraine ranked 63rd among 194 countries[13] and 57th among 172 countries with an index of 49.901 in 2020[14]. The Ukraine`s scores are seen on the Figure 9.

[13] https://ec.europa.eu/futurium/en/system/files/ged/ai_readiness_index_2019__0.pdf
[14] https://www.oxfordinsights.com/government-ai-readiness-index-2020

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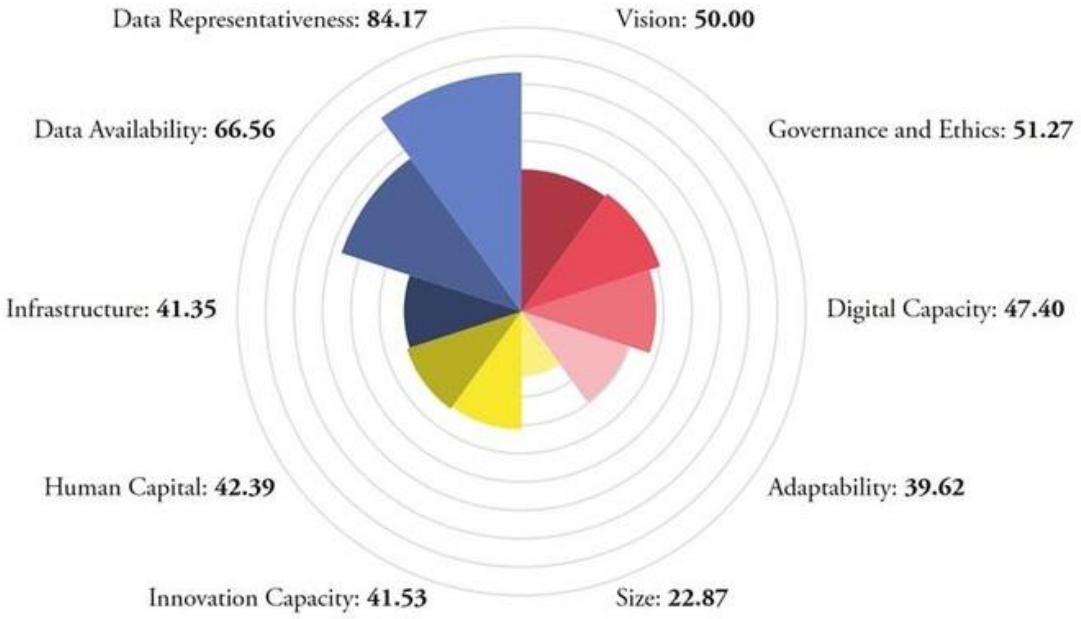

Fig.9 – Ukraine`s scores in the Government AI Readiness Index 2020 rating

Increased investments in AI industry can also be seen through the scientific publishing lens (Halevi, 2022).

The number of research in AI is increasing (see Fig.10). According to Clariative, 251 AI-related papers led by Ukrainian researchers and published between 2017 and 2021 can be found in the Web of Science, the world's most trusted publisher-independent global citation database.

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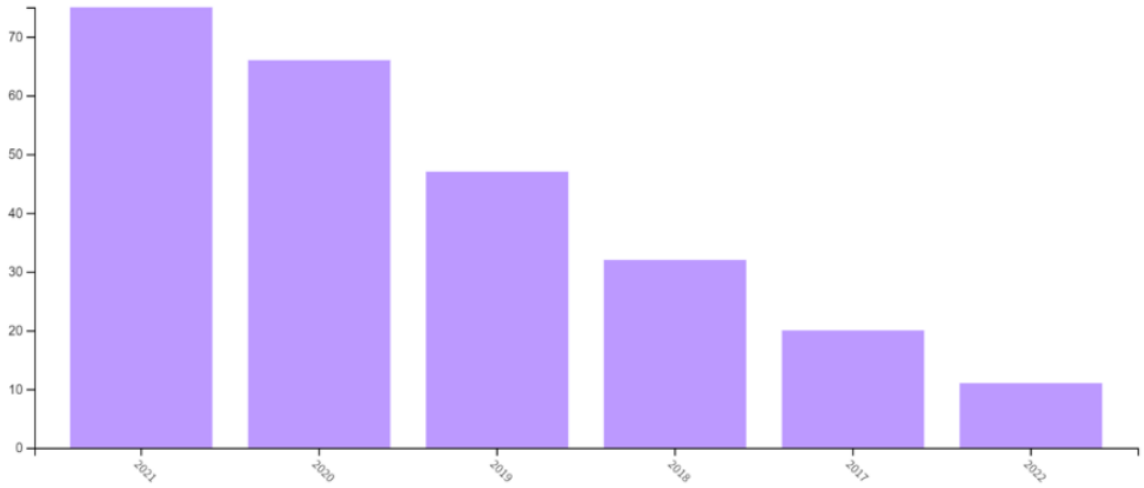

Fig.10 – Ukraine's publications output growth in computer science and artificial intelligence since 2017 (source: https://clarivate.com/)

Aiming at contributing to the growth of AI & ML sector in Ukraine, several Governmental initiatives were launched.

The Expert Committee on the Development of the Artificial Intelligence (http://www.ai.org.ua/) under the Ministry of Digital Transformation of Ukraine was established at the end of 2019. The main task of the committee is to increase Ukraine's competitiveness in the field of Artificial Intelligence.

At the end of 2020, the Cabinet of Ministers of Ukraine adopted the National Strategy for Development of Artificial Intelligence[15] developed by AI experts and industry professionals. Before its adoption, the Ukrainian AI strategy was reviewed by 30 internal experts, 200 external experts and more than 30 government bodies. The process of approval took several months and was reviewed by 24 ministries (3 people from each ministry), which means that more than 400 people were involved.

According to the Strategy, AI became one of the priorities in the field of science and technology research. "Artificial intelligence is becoming one of the key transformational technologies of the economy, defense, public administration. Ukraine's success largely depends on its ability to use and increase its existing

15 https://wp.oecd.ai/app/uploads/2021/12/Ukraine_National_Strategy_for_Development_of_Artificial_Intelligence_in_Ukraine_2021-2030.pdf

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potential in the field of artificial intelligence." said Mykhailo Fedorov, deputy prime minister and minister of digital transformation of Ukraine in August 2021[16].

The experts decided that the key to the success of quick development of Ukrainian AI is people. Therefore, human capital development is prioritized in the Strategy[17] and the focus is on several areas of AI, where the country can achieve a leading global position. The Strategy seeks to reform the educational system in order to provide the next generation of Ukrainian tech companies with the AI talent and qualified human capital necessary to drive the country forward. It also aimed to accelerate the introduction of AI technologies throughout the Ukrainian economy to safeguard the global competitiveness of sectors ranging from heavy industry to agriculture (Deep Knowledge Analytics, 2022).

Most AI experts in Ukraine believe the two sectors that offer the greatest potential for progress are education and defense. The coronavirus crisis has created huge disruption within education systems around the world. A generation of schoolchildren has found itself forced to spend much of the past year engaged in distance learning. This has opened up unprecedented opportunities for technological solutions utilizing AI. These new habits are likely to outlast the impact of the pandemic. Meanwhile, the Russian invasion of Ukraine drives demand for AI innovations that will boost Ukraine's defense capabilities while saving lives. Ukraine's agriculture sector is another area of the economy with obvious AI potential. The vast and rapidly modernizing Ukrainian agricultural industry is the ideal breeding ground for AI developments, with numerous success stories already demonstrating the ability of local ag-tech startups to expand on the international stage (Goncharuk, 2021).

Ukraine has a vibrant community of AI professionals and enthusiasts. The country hosts many Big Data/AI/ Machine Learning events including international conferences such as AI Ukraine Conference, AI & Big Data Day, JEEConf, etc. Local communities also organize regular meetups and workshops for big data and analytics experts, such as Bottleneck Night AI/ML, DS Success Meetup, just to name a few.

Many AI-powered multi-million startups were born in Ukraine or created in collaboration with Ukrainian software engineers. Among them:

- People.ai (https://people.ai/) is an AI platform for enterprise sales, marketing, and customer success that uncovers every revenue opportunity

[16] https://good-time-invest.com/blog/who-and-how-is-developing-artificial-intelligence-technology-in-ukraine/
[17] https://aiconference.com.ua/en/news/sferi-primeneniya-tehnologiy-iskusstvennogo-intellekta-v-ukraine-kontseptsiya-kabmina-i-ee-osnovnie-zadachi-101379

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from every customer. In 2021, it became a "unicorn" by reaching a market value of 1.1 billion dollars.

- Cargofy (https://cargofy.com/) is an AI-enabled solution for cargo delivery optimizations. It works according to an Uber-like business model and connects truck drivers with customers that need cargo delivery.
- Grammarly (https://www.grammarly.com/) is the US-Ukrainian startup that has Natural Language Processing technology at its core. It is a cloud-based typing assistant that reviews spelling, grammar, punctuation, clarity, engagement, and delivery mistakes, raised a total of $200 million in funding over the Private Equity in November 2021.
- Neuromation (https://neuromation.io/) is a leading Enterprise AI solutions and platform provider. The company's Neuro platform is a best-in-class machine learning development tool enabling rapid model iteration with an unparalleled developer experience.
- 3DLOOK (https://3dlook.me/) is a mobile body scanning solution that aims to change the way people shop.
- Reface (https://hey.reface.ai/) is an AI powered app where people can swap faces in the videos, GIFs and images in just a few seconds.
- Petcube (https://petcube.com/), a highly crowdfunded Ukrainian startup, leverages machine learning models for its pet detection technology.
- DataRobot (https://www.datarobot.com/) is a machine learning platform that helps enterprises build predictive models at speed. The company has an R&D office in Kyiv, with up to 200 employees working there, according to DOU.UA, an authoritative local IT industry resource.

However, a study[18] of the Ukrainian labor market in the field of Data Science and AI that was made by the Ukrainian Catholic University shows that despite the huge hype and a significant number of AI-related activities, AI and Data Science are still not very popular on the big Ukrainian labor market. They analyze the market by tracking the number of the vacancies on big Ukrainian recruitment platforms. Results of the study made in 2020 are shown on the Figure 11.

Although the national AI labor market seems currently underdeveloped, the changes are expected in the nearest future due to the world tendencies and the emergent shortage of data specialists at the global labor market.

[18] https://apps.ucu.edu.ua/articles-and-research/data-science-job-market-2020-1/

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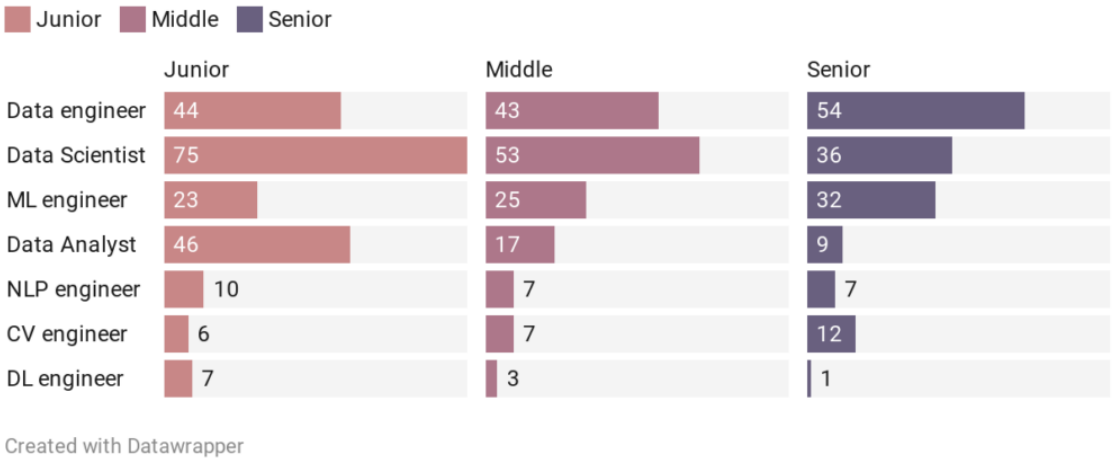

Fig.11 – The number of the vacancies tracked on the Ukrainian recruitment platforms in 2020

B. Obstacles and challenges in implementing AI solutions

Implementing AI solutions for the first time can easily mean new obstacles, challenges and changes in a company's life. What are those challenges? Feel free to list any examples from any national companies.

Ukraine has a chance to move forward in the context of the Fourth Industrial Revolution. But this requires drastic changes in the country's economy. The factors that hinder the process of digitization of the Ukrainian economy are (Bogoyavlenska et al., 2021):

- Underdeveloped innovative ecosystem.
- A high level of bureaucratization.
- Lack of clear understanding by performers on places of ways of realization of the concept of Industry 4.0.
- Insufficient funding, which does not allow to implement innovative smart projects.
- The global pandemic caused by COVID-19.
- Lack of state incentives for entrepreneurs to change business processes. During 30 years of its new history, Ukraine never had a consolidated and modern agenda for industrial high-tech sectors (Yurchak, 2022).
- The outflow of intellectual elite abroad (in particular, IT specialists).
- Weak interaction between the state, entrepreneurs, community.
- Low innovation activity of small and medium enterprises;
- Obsolete equipment at enterprises and lack of free funds for reequipment;

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- The complexity of decision-making on implementation changes.

As for AI startups infrastructure, Ukraine is facing local and global challenges:

- unprepared legislation and the lack of government incentive. As for 2019 Ukraine lacked the legal structure to accommodate venture capital funds, according to Oleksandr Borniakov, a deputy minister for digital transformation in 2019. Today, Ukrainian legislation is still not at all adapted to work with startups, the venture capital market and their respective development (Deep Knowledge Analytics, 2022).
- The lack of venture capital. This problem isn't unique for Ukraine. Globally, the world has seen a decrease in venture activity and a tendency to invest in companies that already have a finished product and, in some cases, revenue, according to DataRoot Labs COO Yulia Sychikova[19]. Tech startups "need to grow in fertile soil that is constantly watered with startup investment rounds," says Alexander Soroka, the CEO of Startup.Network, a professional network for participants on the venture market. "And ours (Ukrainian) is starting from a very arly stage, with angel investors. And finding them is very challenging, not to mention later rounds."
- Undeveloped infrastructure and week communication between startups and potential investors (Deep Knowledge Analytics, 2022). The existing business incubators and various venture funds do not have enough qualified staff to assess the prospects of a project, the risks and feasibility of investing.
- The migration of new business outside the country. Young entrepreneurs consider the United States or European countries to be the best environment for their business development.
- Insufficient protection of private investments.
- Raider risks.
- A lack of intellectual property protections.

Among key problems for AI Market in Ukraine experts name (Deep Knowledge Analytics, 2022):

- the need for solid educational ground in AI & ML field. Low quality education at public institutions. Only few Ukrainian universities have divisions focused on AI (NURE is among them). Therefore, people who want to get into AI & ML field and have certain skills, get the basics of the discipline in other ways (private educational courses, online-courses, foreign educational programs). The shortage of AI experts is also partially provoked by the companies, attracting university professors into commercial sector.

[19] https://www.kyivpost.com/technology/ukrainian-ai-struggles-to-overcome-local-global-problems.html

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- The lack of managers with fundraising experience. The culture of IT-product entrepreneurship in Ukraine is quite young. Ukrainian entrepreneurs need to get experience in product development organization and skills in fundraising.
- The need of network-based industry events. Current events are mainly focused on PR and do not facilitate creation of new partnerships, exchange of the international experience and development of the AI ecosystem in Ukraine.
- The absence of defined specialization of Ukrainian AI market. Although Ukraine has a potential to become global AI player, from the tactical point of view, it's essential to focus on a few market segments in medium perspective. The practical application of artificial intelligence is at the intersection of different disciplines. Creating and applying a good AI solution requires domain knowledge, programming and math, as well as the data and business space in which these solutions will be piloted and developed. According to Oleksandr Krakovetskyi, co-founder and CEO of DevRain, to become a world leader in artificial intelligence, a country has to have good technology, have an ability for systematization, expertise at the state level, strong universities and the market. With few exceptions and great potential, Ukraine does not yet have all these or are at the initial stage of development. However, it can become a leader in one or more specific narrow areas - for example, in the use of artificial intelligence in agriculture, certain areas of medicine or e-sports[20].
- Lack of market-focused analytical and investment platforms.
- The lack of data and the poor quality of available data. According to the Global Open Data Index, which provides the most comprehensive snapshot available of the state of open government data publication, Ukraine hits the 31th place among 94 countries[21]. There is also a problem with personal data – there are legal obstacles for using it.
- Cybersecurity risks. Many data breaches have already occurred in an effort to collect data for AI initiatives.

However, starting from the 24th of February 2022 the major challenge for any developments in Ukraine is the russian full-scale war against Ukraine.

According to Ukrainian Startup Fund[22] in March 2022:

- 24,3% of all Ukrainian startups continued working, 46,7% – worked partially, 28% – did not survive, 1% – changed their field of activity.

[20] https://mind.ua/openmind/20221401-svitle-shi-majbutne-yak-ukrayini-zakripitis-na-svitovij-karti-shtuchnogo-intelektu
[21] https://index.okfn.org/place/
[22] https://usf.com.ua/startup-voice-rezultati-opituvannya-startap-ekosistemi-ukraini/

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- 99% of surveyed companies needed additional funding.
- 41.1% of surveyed companies didn't have enough savings to continue working.
- 37.4% of surveyed companies needed relocation of the team.

C. Best practices for using AI to upgrade companies to Industry 4.0./5.0

Please, list any best practices from national companies who successfully implemented AI solutions to keep their business up-to-date and stay competitive. How did these solutions help them to continue their operations and increase their profit? How does implementing AI support their internal and external processes?

Use case of Bookimed

Bookimed (https://bookimed.com/) is an international medical tourism platform founded in 2014 by Yevhenii Kozlov and Ievgen Khotianov to provide solutions for treatment abroad. They provide people with the platform for hospital search and treatment arrangement. The company started to work with 5 employees to help cancer patients from Ukraine and neighboring countries find hope for cure abroad. Since then, the geographics of the patients have expanded greatly. By now Bookimed has helped more than 570 thousands of patients from all over the world. In 2017, the company raised $500,000 in funding from AVentures Capital, a leading investment fund in Ukraine. In 2018 the team already counted 87 people.

Every patient request is processed by certified doctors - coordinators. They help with hospital choice, paperwork, and medical trip arrangements. When the amounts of the processed information on the platform, including the information about doctor coordinators, patients and hospitals providing various treatment options have essentially increased, a company faced a bottleneck in the processes and a need to improve their operations.

A new AI-system was developed by another Ukrainian company DataRoot (https://datarootlabs.com/) for Bookimed to find the best possible match between patients and doctor coordinators. Doctors have different medical backgrounds and can work with specific kinds of people. The patients can also be different from person to person. DataRoot developed an analytical data-gathering system that obtains patients behavioral data from Bookimed website, such as, countries, content that attracted patie look at different pages, type in different queries and spend differing amounts of time on our pages. There are more than 300 different behavioral parameters for the users on the website fed to a neural network which will determine which doctor coordinator will match the specific needs of a

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customer. In order to find out what kinds of patients can work well with them, the neural network can analyze all background cases of doctor coordinators.

A neural network continues to learn from the patient-doctor interaction data. A tutor system is set up through which doctors can teach the network about the items that are not interesting or appropriate for them. The system is working autonomously. After the launch of the system the conversion rate has increased and it continues to grow, as well as the company`s profits.

Use case of PrivatBank

PrivatBank (https://privatbank.ua/) is the largest bank in Ukraine. It serves more than 19 million customers. The bank analyzes a huge amount of data: from geographical coordinates and routes to customer preferences on social networks. The main sources of information collection include the following:

- POS-terminals, ATMs and self-service terminals. They allow you to track the priority routes on which the client goes most often.
- Accounts in social networks. If a user logs into a banking widget through social networks and agrees to give the bank access to the account (for example, to raise the credit limit), then there will be more data about him. You can find out with whom he communicates, what kind of content he likes. Based in this information, it's possible to use predictive analytics (predict customer behavior) and identify unscrupulous customers.
- "PrivatMarket", an e-commerce platform from Privatbank where individuals buy goods, and companies make purchases. The bank analyzes customer preferences in order to understand which products to offer.

This data is analyzed using special AI-software, then scoring is carried out. For example, a credit history of people from the environment of a borrower can become a predictor. Data about this could be taken from social networks. If the client's friends and acquaintances do not repay their debts, the bank believes that he will do the same. Moreover, even musical preferences are important. Privatbank has found that lovers of chanson worse repay debts than fans of jazz and light music.

It's difficult to assess the overall economic effect. However, there are some specific cases. For example, due to accurate analysis, it was possible to additionally attract UAH 1 billion of deposits (about $ 40 million).

Visa in collaboration with PrivatBank has rolled out its Visa Token Service in Ukraine that offers a secure environment to speed up innovation in e-commerce and mobile payments. The platform analyzes the number of transactions, their volumes, time, place and other parameters that will allow banks and businesses

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to determine the segment of customers for which the provision of discounts or other offers will be most attractive. The service is available to Visa cardholders with NFC-enabled mobile devices that run on the Android operating system

Usecase of Lactalis Ukraine

The Lactalis Group is a French family company with almost 90 years of history. With 266 plants in 55 countries and more than 85,000 employees worldwide, the Group is one of the world biggest dairy products manufacturers that owns international brands Président, Galbani and Parmalat. Lactalis Ukraine (https://lactalis.com.ua/) is one of the important divisions of Lactalis Group in Eastern Europe. In 1996, the Group established a joint French-Ukrainian enterprise with Mykolayiv Municipal Dairy Plant. Today, Lactalis manufacturing sites in Ukraine produce almost 250 products under the brands Président, Dolce, Lactonia, Lactel, Fanny and LokoMoko. The company employs more than 750 employees in different regions of the country.

In 2020 Lactalis Ukraine realized the need to rebuild their merchandise and data processes to enable better control over the sales. The main goal was to get a deeper understanding of how Lactalis merchandise works and how the company can improve the work with the shelves in retail shops.

A new AI-based image recognition solution Picsell developed by Outforz (https://outforz.com/) was introduced to the merchandise processes.

It allowed:

- automatic detection and verification of the correct location of the SKU on the shelf;
- detection of out of stock on the shelf;
- comparison of the location of the SKU with the planogram;
- estimate the number of facings on the shelf;
- estimate the length of the shelf;
- monitoring the prices of competitors' products;
- monitoring the performance of merchandisers, including task management system and motivational program.

The product is based on a self-learning neural network automating the verification processes for SKUs with an accuracy of 95-98%.

The company has been able to save 20% of their budget on merchandising at once. They've also been able to gather better data with the shelves visualization tool. As a result, the sales have increased by 10%.

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IV. Conclusions for future entrepreneurs

Please, shortly conclude your research as it would be a message for future entrepreneurs. The summary should contain conclusions based on best practices and it should outline the importance of transition to Industry 4.0/5.0 and implementing AI solutions. What are the biggest challenges that they need to come over in the future? How can they implement these best practices during their entrepreneurship? What are the key skills and competences that they need to develop to be resilient and able to react to a fast-paced business environment?

Industries are nowadays being shaped by two different paradigms: Industry 4.0 proclaims transition to digitalization and automation of processes while emerging Industry 5.0 emphasizes human centricity of industrial processes.

The technological progress has revolutionized modern industries and accelerated the transition towards unprecedented digitization, networking, automation and artificial intelligence. Development periods are getting shorter; individualization of the production on demand is no more news; product development is becoming much flexible and efficient. Several years ago, it looked like digitalization can be a key to all industrial problems. But the life appeared to be more complex.

The current world geopolitical crisis and related hybrid threats (hybrid wars), including the cybersecurity threats in form of massive cyberattacks; wars (such as, aggression of Russia against Ukraine); related refugee and other humanitarian crises have a huge impact on the global industry and economics and particularly on the Industry 4.0 and smart manufacturing. After the first excitement from the digitalization effects, it became obvious that the world requires a much higher level of process resilience, production sustainability, and decision-making quality than it has been foreseen according to the Industry 4.0 concept. This explains the growing popularity of the Industry 5.0 concept, which (unlike Industry 4.0) is supposed to bring humans back into the loop of the industrial processes to address the emergent resilience and sustainability concerns.

Implementation of AI should not diminish key aspects of humanity – morality, human relationships, cognitive acuity, freedom and privacy and the dignity of work. A virtues-based approach should be used to resolve ethical dilemmas, rather than utilitarian ethics.

The biggest challenge that awaits future entrepreneurs is to find reasonable ways to marry the two extremes of automation and value-based human-driven processes, which inherits the most valuable features of both - efficiency of the Industry 4.0 processes and sustainability of the Industry 5.0 decisions.

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Successful co-existence of Industry 4.0 and Industry 5.0 concepts would mean increase of productivity without removing human workers from the manufacturing processes. It is also impossible without further development of collective intelligence technologies enabling human and machine collaboration, a.o. for efficient value-based decision making.

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