Fourth industrial revolution as a driver of the digitalization of production and urbanization

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Abstract

The article presents a historical slice of industrial revolutions and examines the changes that occur as a result in various sectors and spheres of public life. Authors argue that Fourth Industrial Revolution is reflected in industrial change and training. However, Industry 4.0, which is part of Fourth Industrial Revolution, provides a number of new technologies that lay the foundations for the formation of virtual-real space for data exchange, testing new quality processes and objects, creating robotic systems in combination with Internet technologies in the format of smart factories, "smart" enterprises, smart cities. Authors expressed the opinion that today there is still an intensified so-called "spread" of cities, the expansion of their territory. The transition from simple to group forms of urban settlement – from the usual "point" city to urban agglomerations – compact territorial groups of urban and rural settlements is especially characteristic of modern urbanization. Authors consider digital vector of transformation of national economy in terms of digitalization of production and the importance of urban processes. The article presents four stages of the industrial revolution and focuses on the features of Fourth Industrial Revolution, as a new industrial breakthrough in which the interaction of new information and communication technologies in production processes, urban management and life. As a result, we note that compliance with the principles of Industry 4.0 will allow the rational use of natural, technical and energy resources, recycling of industrial and household waste, to obtain new products or energy.

Keywords: industrial revolution, Industry 4.0, digitalization of production, urban processes, digital transformation.

Introduction

Digital transformation opens up fundamentally new horizons and opportunities for value added in virtually all areas of the economy. Digital transformation is not only about technology, but also about business strategy towards Industry 4.0 in urban production and urbanization. At the present stage, digital technologies are an integral part of the socio-economic life of society and determine key vectors of development of modern cities. Digitalization is becoming a driver of their development, as it is able to ensure their innovation, quality and standard of living in them. Big cities are the engine of the world economy, cultural, historical, spiritual, political and innovation centers, where the most acute global problems of today are often posed and solved experimentally. At the same time, large cities are under considerable pressure from factors such as migration, social inequality, environmental pollution and climate change.

Digitalization of business and industry is the core of digital economy and a major driver of growth, including the formation of Industry 5.0

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(Britchenko, 2019; Kraus, 2018; Andrusiak, 2020). The use of digital technologies starts the process of modernization of traditional spheres of economy and stimulates the emergence of new innovative industries that accelerate economic growth of cities and increase the level of competitiveness of the country in the world economic system. Fourth Industrial Revolution is reflected in the change of industry and training. Thus, small and medium-sized businesses use digital sales methods, and large industrial enterprises carry out deep digitalization of production, urbanization is accelerating. Training of specialists in digital entrepreneurship and urban economics and urban planning is announced in educational institutions.

Industry 4.0, which is part of the Fourth Industrial Revolution, provides a number of new technologies that lay the foundations for the formation of virtual-real space for data exchange, testing new quality processes and objects, creating robotic systems in conjunction with Internet technologies in format of smart factories, "smart" enterprises, smart cities. In the 21st century, we are witnessing the development of industry in light of the trends of new industrial age. We are talking about the transition to fully automated and digitized production, which is controlled by real-time intelligent systems in constant interaction with the external environment, going beyond one enterprise, with the prospect of networking them globally.

Therefore, the issue of digitalization of production and urbanization in Ukraine, namely in terms of digitalization, strategic guidelines for digital infrastructure development as an important factor in achieving competitive positions of Ukraine and its cities in global digital space is gaining national importance.

Material and methods

Valuable in the scientific sense of research on the problems of urbanization processes are scientific works and practical research and development of such well-known scientists and inventors as L. Blashchuk (Blashchuk, 2010), O. Baliyeva (Balyieva, 2011), G. Golts, G. Komarnytska (Komarnytska, 2015), D. Kotenok (Kotenok, 2013), V. Milko (Institute of History of Ukraine, 2019), V. Smolii, O. Reyent, V. Shandra, V. Shevchenko. Ukrainian economists are actively involved in systematic research in digital transformation of industry and production. Among them are N. Andrusyak (Andrusiak, 2020), I. Britchenko (Britchenko, 2019), Y. Vlasenko (Vlasenko, 2021), T. Zaporozhets (Zaporozhets, 2019), N. Kraus, K. Kraus (Kraus, 2018), S. Kubiva, O. Maslova, O. Marchenko (Marchenko, 2021), O. Manzhura (Manzhura, 2021a; Manzhura, 2021b), I. Skitsko (Skitsko, 2016), V. Osetskyi (Osetskyi, 2020), O. Shtepa (Shtepa, 2021) and others. But, at the same time, a significant number of problems regarding the vision of the concept of digital development of national infrastructure and socio-economic benefits of industrial revolutions and the 4th in particular, remain insufficiently solved.

The aim of the article is to study digital vector of transformation of national economy in terms of digitalization of production and the importance of urban processes. The identification of possible socio-economic threats and benefits of industrial revolutions was characteristic of society. Substantiation and disclosure of stages of industrial revolutions and urban processes. Analysis of the principles of Industry 4.0 as the engine of the Fourth Industrial Revolution. Introduction to the components of Industry 4.0, which determine the accelerated development of digital production.

Results and discussion

Industrial revolutions are a factor in the development of human capital, the accumulation of knowledge, the development of technology, the search for innovative ways of

processing raw materials, the output of which allows to have minimal costs. Fourth Industrial Revolution is based on a set of stages, factors, resources and processes aimed at implementing the mechanism of digital transformation. In this article we will try to consider the content of digital industry, the peculiarities of all stages of industrial revolutions, present an analysis of inventions of each stage, as well as focus on the essence of the category "Industry 4.0", indicate the general principles of its operation. To begin with, we propose to reveal the meaning of the concept of "industry".

For example, industry is understood as a branch of material production that affects the development of the city and its productive forces. Industry is the basis of industrialization of the economy (Wikipedia, 2022). As for the modern development of cities, it took place at all times due to industrial coups. Today we are at the stage of the Fourth Industrial Revolution. Each of the stages is presented in more detail in Figure 1.

Thus, the first stage of the industrial revolution began in the late XVIII century in the UK. During this period there was a need to mechanize the processes of the textile industry. The creation and use of the first steam engine met this requirement. The engine produced energy that powered the mechanisms. This innovation was the beginning of an industrial revolution. As a result of this invention, the then government aimed to transform handicrafts and home-made production into factory (Zaporozhets, 2019). It was the steam engine that became the basis for the development of mechanical engineering. Steamers and locomotives have reduced the time to transport people and goods over long distances. The British have been trying for a long time to prevent the spread of their startup abroad. The country banned the export of production technology, equipment and skilled labor. However, such secrecy could not last forever. William and John Cockerill, of British descent, mechanized a workshop in Liege. Belgium became the first country in continental Europe to undergo industrial transformation.

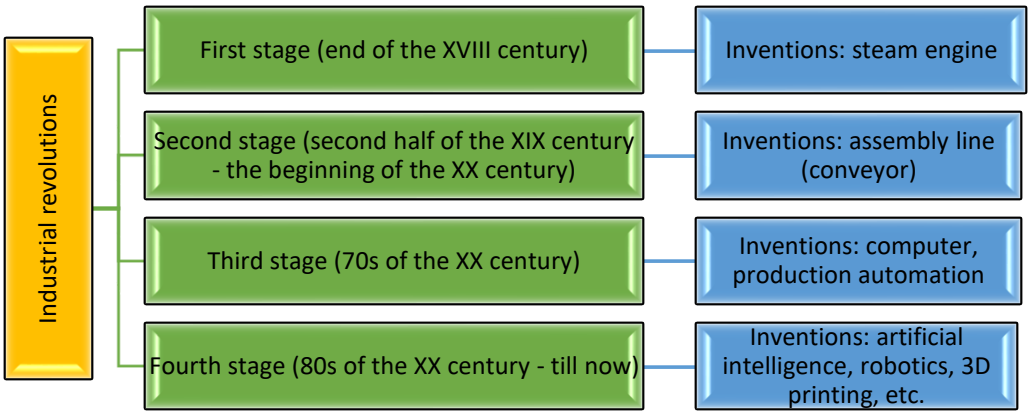

Figure 1. Stages of the industrial revolution (compiled by authors based on source (Zaporozhets, 2019))

The development of industry in France was longer than in Great Britain and Belgium. Because the country was in an unstable political situation. In 1848, France became an industrial state, but did not reach the level of development of Great Britain. Other European countries and cities had somewhat slower industrial development. This is due to the fact that the level of wealth, power and opportunities was lower than that of the British, Belgian and French counterparts (Britannica, 2021).

At the first stage, the industry took the first steps towards replacing manual labor with mechanical labor, which increased the efficiency of the labor force. However, new means of production were expensive, and not everyone could afford them. In the initial stages, people became poorer due to the reduction of staff, lack of knowledge and skills to master new technologies. The standard of living became lower, the worker was forced to work for a meager

wage for a long time, to live in apartment buildings with unsanitary conditions, to endure abuse and exploitation in the workplace. Over time, ideas for solutions to existing financial problems began to emerge. Actions were aimed at improving the level of material amenities (Britannica, 2021).

The second stage of the industrial revolution occurred in the second half of the nineteenth century. Then mankind introduced the use of electricity in the production of goods and created an assembly line that could use conveyor mass production in the 1860's and 1870's. This technology quickly gained popularity in the United States, Western Europe, Japan (Zaporozhets, 2019). Henry Ford took the idea of mass production from a slaughterhouse in Chicago, where each butcher performed only part of the animal's development tasks, not the entire process. He changed his approach to car production. Now the automotive process took place in stages on the conveyor belt, rather than going all in one shop. This reduced costs and accelerated the production process (Desouttertools, 2021). The beginning of the third stage of the industrial revolution came in the 70's of XX century. At that time, computers were being developed and distributed. These computers made it possible to process high-quality information that was previously done manually. The process of computerization was the impetus for the automation of production (Zaporozhets, 2019) and urbanization (the growing importance of cities in society, accompanied by growth and development of urban settlements, growing share of urban population, urban lifestyle in a particular region, country, world).

The modern concept of urbanization is most fully reflected in the publications and studies of the UN NAVITAT (Unhabitat, 2021). Main provisions of this concept can be reduced, in our opinion, to the following:

- Cities are the driving force of modern economy, as they provide a higher level of productivity and welfare;
- The importance of the city as a catalyst for economic development of the country increases with decreasing level of development of the latter;
- Urban lifestyle and typical elements of culture spread from cities to society.

Fourth Industrial Revolution is a new industrial breakthrough, in which there is an interaction of new information and communication technologies in production processes, urban management and life. He introduced the term in 2016. Klaus Schwab, founder and chairman of the World Economic Forum. According to him, Fourth Industrial Revolution will increase incomes and improve the quality of life, but there is a risk of increasing inequality – the poor and low-skilled will work for meager wages, and highly skilled workers will become even richer *(Salesforce, 2020)*. This will have the same consequences as globalization, poor countries will not be able to afford new technologies and will lag far behind highly developed countries such as the United States, Germany, Japan and France.

The use of automatic data processing technology in industrial production introduced the concept of Industry 4.0. It is also known as Smart Factory (Industrial annalistic platform, 2021). For the successful operation of this system, it is necessary to follow the principles presented in Figure 2, namely:

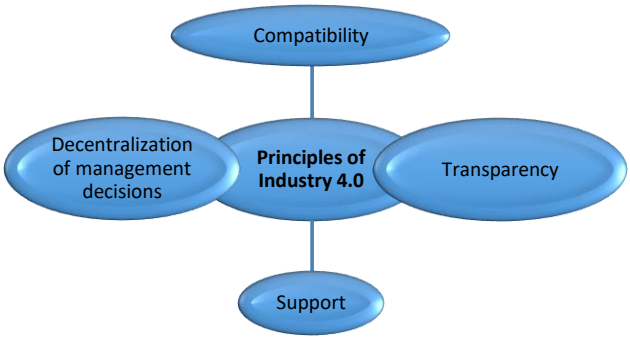

Figure 2. Principles of Industry 4.0 as the driving force of the Fourth Industrial Revolution (compiled by the authors based on source (Forbes, 2017))

- The principle of compatibility, i.e. the smooth interaction of sensors, devices and people and communication through the Internet of Things;
- The principle of transparency arises as a result of interaction. To comply with this, it is necessary to create a digital copy of real objects and functions, which will allow you to display a real physical copy.

This will give the most complete information about the current state of the process;

- The principle of computer support – by collecting, visualizing and analyzing information, computers help people make the right decision based on the actual current state of the object. Technical support for these systems can replace humans in hazardous production conditions;

- The principle of decentralization is to replace human labor with machine, where labor will be more efficient without human intervention. At the same time, employees will act as a controller in case of response to unforeseen situations (Forbes, 2017).

Adherence to these principles of Industry 4.0 will allow the rational use of natural and technical and energy resources, recycling of industrial and domestic waste, to obtain new products or energy (Industry, 2022). Figure 3 clearly shows the nine components of Industry 4.0 that determine the digitalization of production, namely:

Components of Industry 4.0	Big data
	Automated robots and cybersystems
	Simulation
	Horizontal and vertical system integrations
	Industrial Internet of Things
	Application of cloud technologies
	Three-dimensional printing and adaptive production
	Use of virtual reality
	Cybersecurity

Figure 3. Components of Industry 4.0, which determine the accelerated development of digital production (compiled by authors based on sources (RuEmann, 2015; Skitsko, 2016; IT Interprese, 2021))

- Recent Big Data analytics. Due to the use of new information and communication technologies, the amount of data is constantly increasing and there is a need for rapid search for the necessary data and their further processing. That's why Big Data analytics has become an integral part of new industry, digital manufacturing and urban processes;

- Autonomous robots are devices that solve complex problems based on interaction with each other and working with people and learning from them. These works are more efficient than those used in production;

- Now you can see the use of 3D modeling of inventories, products and materials. Modeling, in the future, will be involved in the production process. This tool will display a real-time virtual model of production processes, machines, people and products. Due to this, you can test and optimize the process in virtual reality before its physical use. This will save time and financial resources of the production process (RuEmann, 2015);

- Horizontal and vertical integration is an important part of the production process. Currently, there is a need for interaction of enterprises, departments and companies in a single information environment. Also, in the fourth stage of the industrial revolution, access to the industrial Internet of Things opens up. Connection objects can obtain the necessary information (Skitsko, 2016);

- Industrial Internet of Things, which is a unified system of computers and sensors connected to them and programs for collecting and exchanging information for control and monitoring of production automated processes (IT Interprese, 2021);

- Actively used cloud technologies. But under the influence of Industry 4.0, the amount of information increases and there is a need for storage and rapid response. It is in the "cloud" will be used data and functionality of machines, which will increase the productivity of the production process;

- Three-dimensional printing, which is the basis of adaptive production, which is used to create a prototype of future products or the manufacture of individual parts. When making individual orders using 3D printing, the cost of raw materials and logistics is reduced;

- Use augmented reality used for virtual learning, improve the effectiveness of decisions and work procedures. Workers can receive instructions on how to repair equipment by looking at augmented reality glasses (RuEmann, 2015);

- Cybersecurity as a system to protect computer space, industrial systems and production lines from cyber-attacks and malware. Because Industry 4.0 uses the industrial Internet of Things, the risk of intrusion into a company's computer security increases. For these reasons, at the present stage requires a complex system of identification of machines and users (RuEmann, 2015; Skitsko, 2016);

Summarizing the above, we can conclude that "Industry 4.0" is a new round of development of industry, production and cities. It differs significantly from previous industrial transformations and combines all the benefits associated with it. This transformation has been a strong impetus for a technological and progressive future. Industry 4.0 combines process speed, interactive management, process control with various information and communication technologies, security at all stages and the formation of smart cities. Today there is a so-called "spread" of cities, the expansion of their territory.

The transition from simple to group forms of urban settlement – from the usual "point" city to urban agglomerations – compact territorial groups of urban and rural settlements is especially characteristic of modern urbanization. The nuclei of the largest urban agglomerations are mainly capitals, the most important industrial and port centers. In addition, we see the next stage of urban transformation, the so-called de-urbanization, i.e. the growth of suburbs, migration to rural areas, planning new cities and more. In developed countries, the average level of urbanization is 71%, and in developing countries – 33%. The pace of urbanization largely depends on its level. Nowadays, the urban population in developing countries is growing 3 times faster than in developed ones. They now account for 1/6 of the total annual growth of urban residents.

The search for ways to accelerate the digitalization of production and urbanization in Ukraine lies in the formation of a new paradigm coordinate system of digital economy, identifying forms and methods of influencing digital development of cities and industry, deploying logical-structural scheme of digital transformation making decisions aimed at ensuring inclusive economic development of cities and finding opportunities to implement the strategy of technological breakthrough in terms of their digital transformation.

With the spread of the fourth stage of the industrial revolution, large cities began to think about the future in the context of intensive development of smart technologies. Thus, the city has a need to attract new information and communication technologies in the management of the city to improve the quality of life, safety and comfort of residents and guests of the city. All this was combined into one concept of "smart city". Smart city is a new approach to the city, which combines digital, human and physical systems into a single environment, which aims at sustainable development and successful future of the city's residents. Back in the 60-70's of XX century the Community Analysis Bureau in the United States used cluster analysis, databases, and aerial photography to gather information and prepare reports on disaster relief and poverty reduction. From that moment began the creation of the first generation of smart cities.

Thus, the first generation of smart cities was to provide innovative technologies to monitor the current situation in the region. The goal of the second generation of smart cities was to integrate technology into a single system for efficient and timely local governance. In the third generation, there is an integration of the public and city leaders (Figure 4).

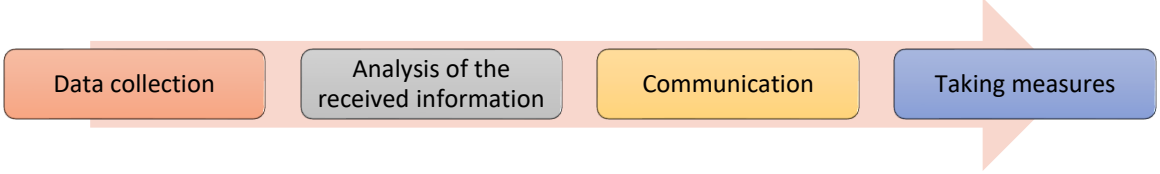

Figure 4. The process of implementing the concept of a smart city
(developed by authors)

Thus, the implementation of the smart city concept includes four such steps – collecting information using smart sensors; analysis of data on the work of city services; communication of the results of the analysis of stakeholders for decision-making; implementation of measures to improve the work of the city. The concept of smart cities is important and relevant, as the population in cities is growing, globalization is taking place. According to UN estimates, about 55% of the world's population now lives in cities, and in 2050 the number will increase to 70%. The planet's population is also projected to increase by two billion by 2050, which will increase the need for sound management of the social, environmental and economic systems. According to the Viennese methodology, the concept of a smart city consists of 6 interrelated components – smart economy, smart movement, smart governance, smart people, smart living and smart environment (Figure 5).

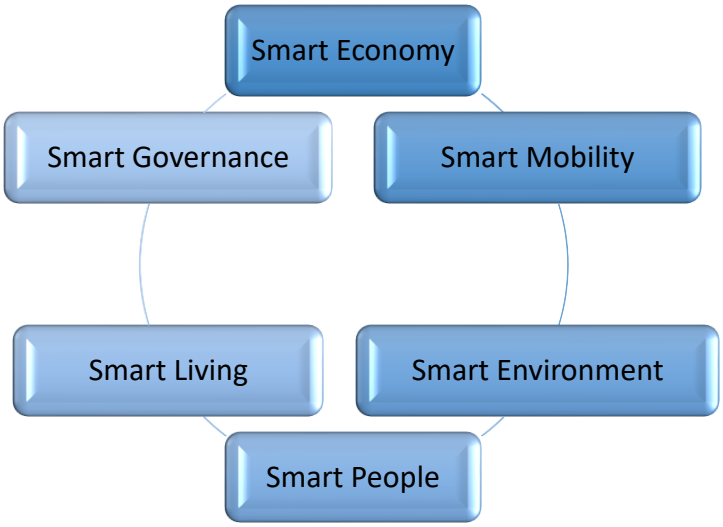

Figure 5. Component models of Smart city
(compiled by authors)

Smart economy is a concept that combines e-commerce, e-business, increasing productivity through the use of information and communication technologies and their collaboration. This category includes economic relations and the reputation of the city, the level of entrepreneurship in the region, the ability to innovate, international relations, labor market flexibility, efficiency of economic activity of the city, the ability to change.

Smart mobility is a new transport network in which:

- A person can easily change several modes of transport;
- Runs several types of transport, which allows the consumer to choose best for the situation;
- The vehicle is replaced with a car with a minimum level of emissions;
- Transport runs on schedule and is guaranteed to arrive at its destination;
- Relocation is accessible to all and provides a better quality of life.

Reasonable movement includes the safety of vehicles, the use of information and communication technologies in infrastructure, domestic and international accessibility of the city. Smart environment is a decision to improve the environment through the use of pollution management systems and the use of alternative energy sources. The aim of the model is to improve the quality of the environment and the use of energy efficiency measures.

A reasonable environment includes the level of pollution, the attractiveness of natural conditions, the rational use of resources and the protection of the environment. Smart people are people who have a desire to learn throughout life, take an active part in public life. In addition, the population of a smart city is educated, creative, open to change. Smart living is a way of life in a city with cultural,

educational and healthcare facilities. Such a city has a high level of security of life, access to education for the population and is attractive to tourists. Smart governance is a way of interactive management, where there is transparent management, public involvement in decision-making for the successful future of descendants.

According to the decision of Kyiv City Council "On approval of main directions of smart specialization of the city of Kyiv" main areas of development of the city as smart are information and communication technologies, pharmaceuticals and creative industry. The development of Kyiv as a modern city is presented in Kyiv Smart City 2020 Concept. The documents describe the existing opportunities for the development of the city, the achieved goals, ways for further development and the expected results from the smart specialization of the city.

The concept has goals such as:

- High standard of living in Kyiv;
- Modern infrastructure of the city;
- City management through the use of modern technologies;
- Adherence to the goals of sustainable development, raising the level of ecology in the city;
- Public involvement in decision-making;
- Take public opinion into account when making decisions.

Kyiv Smart City concept aims to develop and improve the system of management, relocation, education, security, environment, lifestyle and smart innovation (Figure 6).

In Kyiv, several services have been created for residents – Kyiv Smart City application, E-services, resident's office, Kyiv resident's card, electronic kindergarten registration, online doctor's registration, pet register.

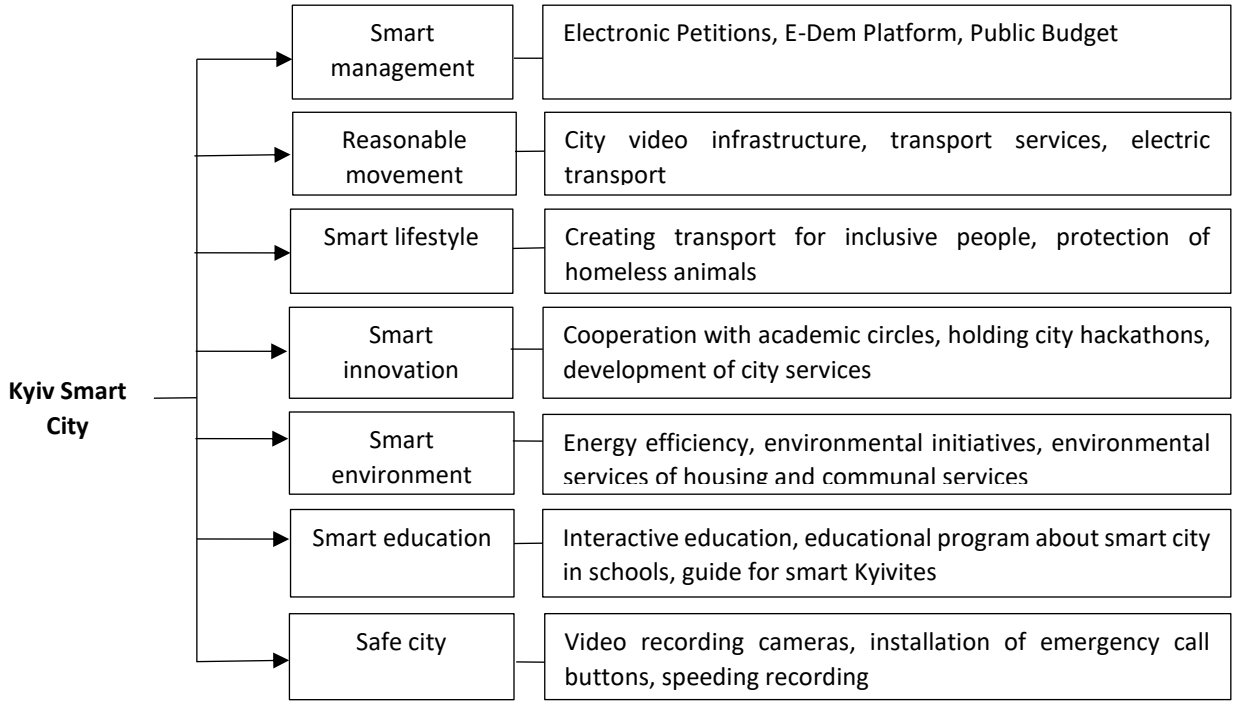

Figure 6. Directions of development of smart specialization of Kyiv
(compiled by authors)

In November 2018, the e-ticket system was launched and Kyiv Smart City mobile application was developed. This application combines all electronic services in the city. With its help you could pay for one-time travel, parking, top up your Kyiv Smart City card, make an appointment with a doctor or register your pet in the Register of Pets.

However, the mobile application did not work for long. On January 5, 2021, the application was forced to suspend its work because the property belonged to a public organization, not the city. And the GIOC contract did not continue. To replace the old application, a new one was introduced – "Digital Kyiv". On the official website of Kyiv Digital,

everyone can monitor the work of municipal vehicles of Kyivzelenbud, Kyivavtodor and management companies. Each car had GPS trackers. Also, these devices are in public transport. You can monitor the movement of vehicles through the Easy Eway application. In "Kyiv Digital" you can see a selection of recommended places for different types of recreation and interests, event posters, virtual tours of cities, useful information and news. Here everyone will find something interesting.

Results of using Kyiv Digital application:

- UAH 3.055 million was paid in December 2021 for parking;
- 320,000 transport cards were sold during the year, about 1 million cards were sold during the whole period;
- In November, the application was downloaded by about 100 thousand users.

In 2022, it is planned to increase the capabilities of Kyiv Digital mobile application. You can now submit an e-petition, monitor air pollution and track transport.

From the use of mobile applications, the city receives an economic effect – an additional source of local budget. Kyiv resident's card – a payment card that has benefits for retirees, people with disabilities, parents with many children, war veterans, etc. Cardholders have free travel, a discount on visits to the zoo, theater, museums, a discount at KP "Pharmacy" and a supermarket.

Also, on the portal of electronic services of Kyiv there is an opportunity to go to the personal account of the resident and have access to all electronic services of the city. Here you can buy an e-ticket, pay a parking fee, enroll in kindergarten, order an e-student, find out information on the RTGC service, apply for a plenary session, get social protection (order rehabilitation equipment, register with the Children's Rehabilitation Center, submit application for financial assistance), register a pet, propose a project that you want to implement at the expense of the city budget, submit a petition, etc.

For transparency and efficiency of the city management system were:

- A single web portal has been created;
- Information on planning and use of the city budget is open;
- Introduction of e-procurement through the Prozorro system. Kyiv became the first city to switch completely to e-procurement;
- Display of open data;
- Information and analytical system "Property". Here you can get information about the objects of the city.

Kyiv Contact Center is an organization to which city residents turn to express dissatisfaction or suggestions regarding the work of structural units of Kyiv City State Administration, utilities and other contractors. So, Kyivans at number 15-51 or on the website of the municipal institution can express their opinion and be heard. City security is one of the city's development priorities. More than 7,000 video surveillance cameras, more than 60 emergency call buttons, speed cameras, face and car number recognition systems have been installed in Kyiv.

Smart lighting has been installed to save local budget costs. In Kyiv, incandescent lamps were replaced with LED lamps with an automated lighting control system. This technology has made it possible to reduce electricity costs in 2019 by UAH 25 million.

Based on the above, it can be concluded that the concept of "smart city" combines components of security, education, innovation, harmony with the environment, favorable environment for economic development in the region, smart governance and movement. Kyiv is following this path. At this stage, there are already electronic services and services for residents, installed CCTV and speed cameras, emergency call buttons, etc. However, much remains to be implemented and improved in the capital.

European continent is currently undergoing a period of change. Automation of production, globalization processes, the use of new technologies have influenced the current state and directions of development of cities, business and the economy as a whole. In such conditions, cities find their way to improve their strengths and reduce the impact of threats and problems. This section will consider development strategies and

priorities, own development of cities on the way to smart specialization. Smart City Index 2021 published a rating of smart cities (Figure 7). Zurich, Oslo, Lausanne, Helsinki, Copenhagen, Geneva and Bilbao are among the top European cities.

1. Singapore	2. Zurich	3. Oslo	4. Taibe	5. Lausanne
6. Helsinki	7. Copenhagen	8. Geneva	9. Auckland	10. Bilbao

Figure 7. Ranking of smart cities in the world in 2021

To study the European experience of smart specialization of cities, the features of targeted development programs and an innovative approach to solving pressing problems of the city will be considered. Let's start with Zurich, because this city took first place among the European continent.

Zurich is located in the north of Switzerland. The city is a center of finance and banking. The city estimates that Zurich's territory will increase by a quarter in twenty years. This can lead to a number of problems that the Zurich Strategy 2035 aims to address.

The strategy has the following goals:

- Use of innovative technologies and creation of an attractive business environment;
- Sustainable development of the city and rational use of limited resources;
- High quality of life and equality of the population.

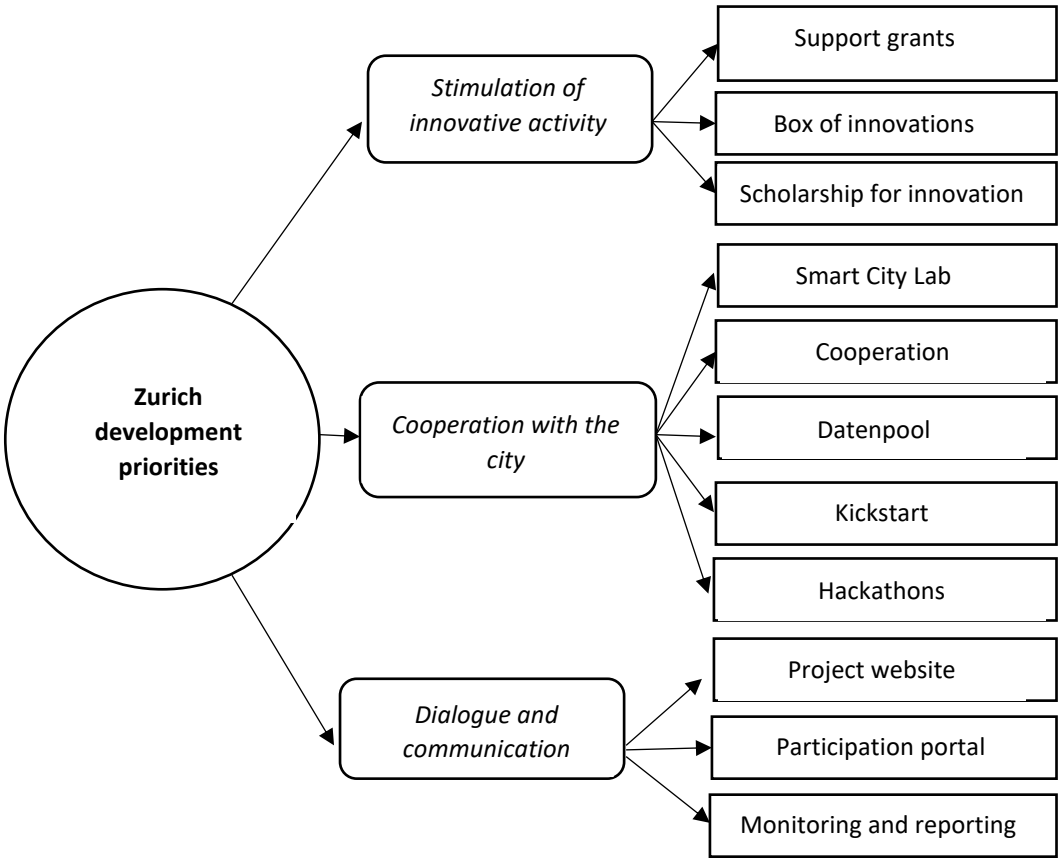

Figure 8. Zurich development priorities
(compiled by authors)

The city of Zurich has taken as its basis such development priorities as (Figure 8):

1. Stimulation of innovation activity. Several types of incentives were planned during the development of the strategy:

- Grants to support innovative projects are funds allocated from the city budget for the initial funding of new projects. Preference is given to projects implemented in conjunction with various services.

- Innovation box for staff – this can be used by employees of the city administration. They are given the opportunity to develop their own idea and take part in an open innovation process. This approach allows you to think purposefully, innovatively, be result-oriented and customer-oriented.

- Scholarships for innovation. University students can use computer experts. Fellows work from six to twelve months in the city administration, exchanging knowledge and innovations.

2. Cooperation with the city. The implementation of this priority is through the implementation of:

- Smart City Lab is a place where everyone can come to share and discuss their innovative project with various partners. Projects are also being tested for viability here.

- National and international cooperation.

- Datenpool. Exchange of administrative data with institutions and the public, display of information from sensors of public infrastructures.

- Kickstart is a program that brings together companies, startups and the public sector.

- Hackathons are an event where software professionals develop innovative solutions to solve the city's problems.

4. Dialogue and communication:

- Project website is the creation of a single site that will display information on the implementation of projects.

- Participation portal creating a single page where people can participate in urban processes and projects.

- Monitoring and reporting – publishing annual reports to inform the public and local councils about the progress of tasks. Monitoring tools are constantly tested, evaluated for accuracy and improved and supplemented.

Norwegian capital has a population of about 650,000. Oslo has experience in reducing air pollution. The city has faced the problem of greenhouse gas emissions from vehicles. One third of the gas emissions in the capital are from cars. Oslo has set a goal to reduce emissions by 95% by 2030. To improve the living standards and health of the population, the mayor decided to create bonuses for owners of cars with zero emissions. Buyers of such vehicles do not pay 25% sales tax, have access to the lane, can use free charging, park and transport ferry. The city's electrical infrastructure includes about 2,000 charging stations throughout the city.

Norwegian capital is also attractive for its intelligent lighting. Oslo has used significant investments to improve street lights. These lighting fixtures respond to weather and light conditions and change the brightness as needed. The implementation of this project has saved more than 60% of electricity costs. Oslo was the first city to use such technology in Europe.

Amsterdam is a compact town with a population density of 4,457 people per square kilometer. Until recently, the city was in constant traffic jams, accidents occurred and there were not enough packing places in the city center. However, they managed to eliminate these obstacles by paving bike paths, Roboat plying. Amsterdam managed to create cycling culture in just 20 years. About 500 km of bicycle paths have been laid in the city, and there are 2-3 bicycles per capita. The result of this transformation is a reduction in traffic flow by two thirds. The city also runs a new mode of transport – Roboat. It is a type of on-demand infrastructure that can be used for passenger transport, garbage collection, delivery of goods and temporary infrastructure (connection of several elements of a boat that creates a bridge).

Ships can carry up to six passengers in the city at a time. Due to the use of navigation technology and cameras with a 360-degree angle of view, the boat can carry passengers from point A to point B without the use of manpower on autopilot. The car can sail at a speed of 12 km/h. Also, the advantages

include the fact that the robot ship is powered by electricity, a quarter of the city is occupied by a canal that allows you to move around the city, higher safety due to the use of new technologies compared to conventional boats, another tourist gem. Modification of the garbage collection vessel serves as a means of waste collection in the historic part of the city and eliminates the need for large garbage trucks, which reduces congestion, noise and pollution.

Smart Flow system works to reduce city traffic in the city. This application manages and monitors sensors located throughout Amsterdam, provides information on traffic flow, available parking spaces and service tariff grid in a specific area. As a result, drivers reduced parking time by 43%, opted for a cheaper option, became quieter in the city center, reduced fuel consumption and air pollution, and calmed down the driving process. In Amsterdam, there is another project to reduce city traffic – Toogethr. This application compares the possible options for passenger transportation and finds people (potential car drivers and passengers) who need to get to the same place at a certain time. Thus, the number of vehicles on the roads and fuel costs are reduced, travel costs are saved, and the negative impact on the environment is reduced.

Another interesting factor in the development of Amsterdam is the initiative to develop a circular economy. Residents strive to reuse resources as many times as possible, and then process them into a new product. Thus, there is a reduction of material for the manufacture of products and waste after its use. To implement this process, a study was conducted, which found that household and household waste accounts for only 18% of waste, and 82% – is household waste. This made it clear that the first thing to look for is a business that needs to be helped to implement a closed-loop economy. That is, the program was aimed at the interaction of the two companies and obtaining the necessary materials from the company that was going to dispose of them to reuse unnecessary resources.

The DGTL festival is taking place in the capital of Netherlands. Here you can listen to modern electronic music combined with lighting and visual effects. By the way, in 2020 it became the first festival to use a closed economic cycle. The following rules apply to DGTL:

- Solar panels provide the festival with light;
- Visitors hand over plastic cups for recycling and receive Eco Coin in exchange. For them you can get a discount on souvenirs and drinks;
- Plastic boards are used to make skateboards;
- Only vegetarian dishes can be bought at the festival, because the meat industry has a negative impact on the environment;
- Food waste after the festival is sent to the farm to create fertilizer;
- Phosphates necessary for growing plants are obtained from collected urine.

In addition, garbage is burned in Amsterdam and benefited from it. AEB operates in the city, where various types of garbage are converted into electricity and raw materials. At the same time, emissions of harmful elements into the atmosphere are minimal. As a result of their activities, 320,000 houses and 600,000 GJ of electricity are produced annually, which provides the city with hot water and heating.

Another option to solve the problem of plastic waste is the startup Ozarka. The essence of the project is that the company rents reusable containers to restaurants and cooking services at the price of ordinary disposable tableware. The scheme of such a model is shown in Figure 9.

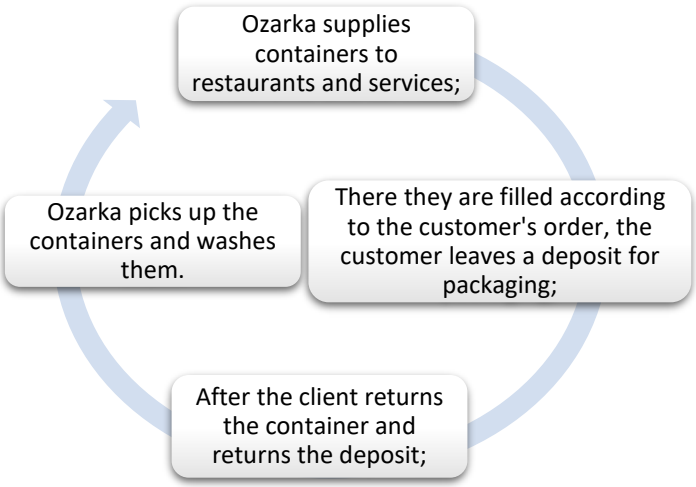

Figure 9. Ozarka startup scheme
(compiled by authors)

In addition to skateboards, Amsterdam also makes street furniture for the city and play furniture for children from sorted plastic. This is what New Raw is doing, which is convinced that plastic is a new raw material, not garbage.

Summarizing the above, we can conclude about new methods of developing smart specialization of cities on the European continent. Here, cities face problems of population growth, road congestion, insufficient number of packing places, environmental pollution by emissions and waste. To solve these problems, measures such as the closed-loop economy, the rational use of limited resources, the use of environmentally friendly vehicles, and the use of tools to stimulate innovative thinking were introduced.

The study of aspects of the industrial revolution, made it possible to draw the following conclusions:

1. In total, four stages of the industrial revolution were passed. The first industrial revolution occurred at the end of the XVIII century, as a result of which the first steam engine was created. The second revolution gave humanity an assembly line. During the third industrial revolution, production automation and the computer were invented. The fourth industrial revolution brought together all information and communication technologies for successful city management, comfortable and safe living. This prompted the launch of Industry 4.0 concept. The new level of industry is guided by the principles of compatibility, transparency, computer support and decentralization. The concept includes components such as autonomous work, modeling, big data, industrial IoT, virtual reality, cloud technology, cybersecurity, adaptive manufacturing, horizontal and vertical system integration.

2. Under the influence of new industrial revolution, the city began to direct development in the direction of smart specialization. Based on this, a new term “smart city” was introduced. It combines the economic development of the city, an innovative system of relocation, the rational use of limited resources and the use of alternative energy sources, the circular economy, raising public education, smart governance and living. Kyiv Smart City concept revealed the essence of ways to develop the capital’s smart specialization. This document is grouped by areas of development such as smart governance, relocation, lifestyle, innovation, environment, education and a safe city. As a result of the implementation of the concept, an electronic services portal, Kyiv Digital application, Kyiv resident cards, CCTV cameras and speed cameras, an open data portal, a contact center of the city, etc. appeared in Kyiv. Due to the implementation of the concept in the capital, additional sources of filling and budget savings have appeared, the level of trust in the decisions of local authorities has increased, the city has become safer and more open to innovation.

3. European continent is sailing on the wave of global digitalization and gaining experience in the development of smart specialization of cities. The strategies and development priorities of three smart cities such as Zurich, Oslo and Amsterdam were analyzed. Zurich took second place in the Smart City Index 2021. The city has the following priorities – stimulating innovative development, cooperation with the city, dialogue and communication. The next place in the ranking was taken by Oslo. The experience of Norwegian capital was interesting because the city has created all the conditions for comfortable and economical travel by electric vehicles. There were also investments in smart lighting, which reduced local budget expenditures. However, the most innovative city was Amsterdam. There is a developed cycling culture and the Roboat ship, the Smart Flow parking system and the Toogethr application, which combines passenger and driver to move together, reduce road traffic and save on travel, etc. In turn, the city supports the circular economy initiative. Moreover, local authorities are creating programs to help businesses implement waste-free production and reduce waste after using the product. In addition, Dutch

capital has a closed-cycle DGTL festival, burning garbage to generate electricity and heat, a startup Ozarka that rents out and washes reusable containers for restaurants and cooking services to reduce use. plastic disposable tableware.

Conclusions

Finally, the technological advances of Fourth Industrial Revolution are becoming key drivers of digital transformation of industry and production, the essence of which can be understood by examining the current changes in the economy and considering new technologies and practices related to digitalization. Different views on what technologies and related practices are determinants of the process of digital transformation of production and growth of cities with a population of millions are an illustration of the fact that we are now at a kind of "boiling point", and systematically describe what is happening is difficult.

The nature of the processes of digital transformation of production and industry, which act as a qualitative leap, or a civilizational shift, according to the transformational concept of transition states, interrupt the slow evolutionary development. Digital transformation has led to increased research interests in finding a model for the development of economic systems in these conditions, as such transformations can create incredible opportunities to improve the welfare of the population by addressing pressing social issues: from health and education to the environment; and a large number of negative side effects, including the displacement of labor by machines and artificial intelligence, social and property inequality, the risk of global conflicts over technological supremacy, cybercrime and more.

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