MEASURING THE LEVEL OF DIGITAL MATURITY OF BULGARIAN INDUSTRIAL ENTERPRISES

Assoc. Prof. Valentina Nikolova-Alexieva, PhD¹  Assoc. Prof. Toni Bogdanova Mihova, PhD²
University of Food Technology – Plovdiv Plovdiv, Bulgaria¹
Technical University-Branch Plovdiv, 116 “Al. Stamboliiski” Blvd., Plovdiv, 4000, Bulgaria²,
valentina_nikolova@abv.bg expert2009@abv.bg

Abstract— Bulgaria is considerably lagging behind the general trends in the EU for the introduction of a digital society and it is therefore necessary to adopt specific measures and to focus efforts on overcoming the lagging behind. Creating the right conditions for the introduction of Industry 4.0 will support, on the one hand, the competitiveness of production and attracting investment in the economy and, on the other, will help to increase efficiency in optimal resource use. The aim of the study is to reveal the possibilities for digital transformation of the Bulgarian business and to give recommendations for process transformation, using adequate strategic tools. The results of the study show that investment and innovation in IT are a key factor in boosting productivity in the EU and it is expected that three quarters of the value of the digital economy will come from traditional sectors (industry), so it is crucial to support its digital transformation.

Keywords— industry 4.0, digital transformation, process optimization

Introduction
At global and European level, the impact of digital technology, in particular in the manufacturing sector, is a strategic priority. The development of new generations of digital technologies is a leading factor in building a competitive national economy over the next decades [1]. Bulgaria is considerably lagging behind the general trends in the EU for the introduction of a digital society, and it is therefore necessary to adopt concrete measures and to focus efforts on overcoming the lagging behind. Establishing appropriate conditions for the deployment of Industry 4.0 will support, on the one hand, the competitiveness of production and attracting investment in the economy and, on the other, will help to improve resource efficiency [2]. The need to introduce digital infrastructure is driven by the rapid growth of new technologies leading to unprecedented automation and digitization of real manufacturing and business processes and creating added value [3]. In this context, it is advisable to create an innovative and high-tech platform to support the work and development of industrial enterprises from the traditional sectors of the economy, both in Bulgaria and abroad [4]. There is a social networking business and a single centralized digital information register for companies operating in different sectors. This platform should be designed to provide technological tools to deliver more markets and greater growth in business exports [5].

The aim of the study is to reveal the features and tools of Industry 4.0 and to provide guidance for creating an adequate digital infrastructure to support the transformation of Bulgarian industrial enterprises.

The main task is related to the study of the world trends in the development of the meat products market and the expected technological and organizational changes for the period 2015 – 2020.

The subject of this study is the Bulgarian enterprises from the traditional sectors of the economy.

The subject of the study is the possibilities for digital transformation and process optimization under the conditions of Industry 4.0.

The research supports the main research hypotheses, namely by identifying the global trends for the development of technologies and innovations in conditions of strong competition and determining the position of the Bulgarian industry in the economy of Europe and the world. Bulgarian enterprises in the sector could increase their competitive potential as respond with the adequate strategic tools for digital transformation.

In the present study, the following methods were used: analysis and synthesis; cross-analysis, induction and deduction; analogy and comparisons; quantitative methods by statistical processing of SPSS (one-dimensional, two-dimensional distributions, Χ²-square and correlation coefficient).

Data and information from NSI, NSI, SAPI, Agrostatistics Department at MAF, Marketing and Market Research Agency ICAP, EUROSTAT and others were collected and analyzed, which were analyzed and synthesized. Studies, strategies, outcomes and guidelines of work from national and regional programs have been used.

Exposition
1. The essence of digitization
In the global and European context, the impact of the use of digital technologies, in particular in the manufacturing sector, is a strategic priority [6]. The development of new generations of digital technologies is a leading factor in building a competitive national economy over the next decades [7]. The need for digital infrastructure is driven by the rapid growth of new technologies leading to unprecedented automation and digitization of real manufacturing and business processes, and the creation of added value [8], [16] [17]. Bulgaria is considerably lagging behind the general trends in the EU for the introduction of a digital society and it is therefore necessary to adopt concrete measures and to focus efforts on overcoming the backlog [9]. Establishing appropriate conditions for the deployment of Industry 4.0 will support, on the one hand, the competitiveness of production and attracting investment in the economy and, on the other hand, will help to increase efficiency in optimal use of resources [10], [13].

This requires entrepreneurial thought and action to create an innovative and high - tech platform to support the work and development of enterprises and business organizations in all sectors in Bulgaria [11], [12], [14]. It is necessary to create a social network of businesses and a single centralized digital information register for the working companies from different sectors [15], [16]. It is necessary for this platform to provide technological tools to ensure more markets and greater growth in the export of businesses.

The concept of digitization comes from English (digital). It is considered as a process of transforming information from analog media (text, sound) into digital form using electronic devices, ie converting analog information into digital. This allows information to be processed, stored and transmitted in a digital environment to the user regardless of its location through computer networks, the Internet, social networks, etc.

The main objectives of digitization are to preserve the analogue information resources and their long-term storage in the form of digital copies, as well as to provide access to these copies through digital devices and networks and their collection in digital libraries [12].

Digitization is seen not only as a process of digitizing traditional information flows but also as an environment integrating digital resources, services and specialists with the necessary knowledge and skills at the level of the technologies of this environment related to creation, storage, access, use, dissemination , security and information protection.

Digitization provides access to information on the global network at the same time to many users without any time and space constraints, integration of heterogeneous information flows as well as richer possibilities for their processing, structuring and categorization, use and transfer. Digitization of production leads to intelligent automation of the industry, allowing the free movement of
industrial productions in Europe and the world. Expectations in the future are digital production to reach 3.2 trillion euros in the G20.

2. Industrial evolution

The "revolutionary" changes in industry and the interplay between the main factors of production reveal its evolution over the years. (Figure 1).

- Industry 1.0: The first Industrial Revolution was in the 18th century. It is related to the mechanization of manual labor and the introduction of the power of water, wind, and steam (steam engine) into production technologies.
- Industry 2.0: The industrial revolution of the early 20th century, the associated use of electricity and the use of a "new organization" of production, the basis of mass production.
- Industry 3.0: Introducing computers to aid production in the 1960s and 1970s. This produces automation of production.
- Industry 4.0: Introducing Internet Technologies in Production. They allow the use of different cloud technologies, resulting in so-called large data that is the foundation of organizational perfection.
- Industry 4.0: Introducing Internet Technologies in Production. They allow the use of different cloud technologies, resulting in so-called large data that is the foundation of organizational perfection.
- Industry 5.0: Introducing Biometrics and Biotechnology into Production. Allows biological sensors to be used to control and organize production. The challenge is to use an appropriate open source organic language that allows the use of biological / synthetic cells in industrial production. At present, industrialization is at the 4.0 level worldwide.

2.1. Nature of Industry 4.0

Industry 4.0 is a set of connected digital technology solutions that support the development of automation, integration and real-time data exchange in manufacturing processes. In its essence, this reflects an industrial and technological transformation process that naturally follows the development of scientific and production practices. The fourth industrial transformation is a natural extension of digitization and automation of production and includes Internet connectivity and operation of cyber-physical systems without human involvement, processing and analysis of large information arrays and artificial intelligence, robotics, digital clouds, digital modeling and simulation of the production processes through virtual reality, intelligent automation, mass production of individualized products, appearance of new technologies, creating new business models. Industry 4.0 is defined as part of the application of new digital technologies in the manufacturing sector and includes a broad range of technological solutions and business models that contribute to qualitatively new forms of economic activity. The term Industry 4.0 is defined for the first time by the German Federal Government as the main initiative to adopt a high-tech strategy for the development of German industry in 2011 (part of the strategy High-Tech Strategy 2020 for Germany) years the term appears in specific strategies (for example, the German Trade and Investment Agency). The term "Industry 4.0" is used in the name of eight out of 13 national policies in the EU to digitize production processes.

The main ideas for the development of Industry 4.0 were first published by Dr. Henning Kagermann in 2011, becoming the basis for Manifest for Industry 4.0, presented in 2013 by the German National Academy of Science and Engineering (Acatech). Industry 4.0 is a new step in organizing and managing the Value Added Value chain for the development of digital production (Plattform Industrie 4.0, 2014).

In the US, Industry 4.0 concepts are becoming known through the Industrial Internet Consortium (ICC), which identifies it as "the integration of sophisticated physical machines and embedded systems and devices with network sensors and software that are used to improve the processes of forecasting, control and planning for better business and public outcomes (Industrial Internet Consortium, 2013)."

2.2. Industry 4.0 Features

- Optimization of decision making
  - Decision-making is becoming a key factor in global competition. Using real-time analysis and large data processing (Big Data) capabilities make it possible to make real-time decisions. In the manufacturing area, this means more flexible troubleshooting and optimization reactions across the enterprise.

- Resource efficiency and resource efficiency
  - Industry 4.0 preserves the existing strategic goals that are put at the forefront of industrial production: producing as much output as possible from the available resources (resource productivity) at the lowest possible resource cost for available production quantities (resource efficiency). In this way, cyber-physical systems are able to optimize production processes across the value chain. Moreover, in the production of individual products, each of which is made on demand, efficiency across the production process can be optimized to the maximum extent.

- Individual approach to the client
  - Industry 4.0 allows you to take into account individual and customer-specific criteria for design, configuration, order, planning, production and operation, including the desire to make changes within a short timeframe. Thanks to Industry 4.0 even the production of rare items or the production of a single item of each product can be profitable.

- Flexibility
  - The network based on cyber-physical systems allows the dynamic organization of business processes in different dimensions: quality, time, risk, sustainability, price, environmental impact, etc. Thus, materials and logistics chains are in constant balance. At the same time, design processes can be quickly organized, changing product design and work with disruptions (eg caused by suppliers), or to significantly increase delivery volumes in the short term.

- Potential to create value by offering new services
  - Industry 4.0 makes it possible to create new forms of value creation and employment, for example through the provision of services along the chain. Rich Data Collected by Smart Devices (Big Data) can be used with intelligent algorithms to offer innovative services along the chain. This provides Industry 4.0 with great potential for developing B2B (Business-to-Business) services, namely small, medium and start-up businesses.

2.3. Industry Toolbox 4.0

The industry base of Industry 4.0 is based on intelligent, integrated, embedded and digitally integrated systems that greatly support automation and autonomous management of manufacturing processes. They bring together people, machines, equipment, logistics systems and products that can communicate and collaborate directly with each other. Manufacturing and logistics processes can even integrate intelligently between different companies to make production more efficient and flexible.

In industrial strategies, the following key technologies have been identified for the development of Industry 4.0: Industrial Internet of Things (IIoT), Simulations, Added / Virtual Reality (VR / AR), Autonomous Robots, Cloud Technologies Cloud computing, cybersecurity, 3D printing, horizontal and vertical system integration, Big Data analyzes.

This list is complemented by new technological solutions that will play a leading role: artificial intelligence and cognitive systems, machine self-learning, mobile applications, block technologies, digital platforms and more. The list of technologies that will have a significant impact on the development of society, economy and industrial production in the next 5 to 10 years can not be exhaustive at the current level and dynamics of technological innovation.

The impact of new technologies in Industry 4.0 on production and business processes can be summarized as follows:

- Creating new products and services with built-in intelligence, innovative business models and customization and customization capabilities;
- Digitalization of the overall production cycle, acceleration of the development through digital prototyping and virtual production, flexible organization of the production process;
- Miniaturization as a trend in the production of microchips, electronic devices, implants and others.

2.4 Advantages in Industry 4.0

- Complete new methods of interaction between people and machines;
- New ways of obtaining, storing, processing and moving information;
Decentralized solutions (maximum possible autonomy of cybersystems controlling production machines);
New types of industrial intranet networks.

The Fourth Industrial Revolution has the potential to fundamentally change the structure of the economy as a whole. This means that:

- In the manufacturing process, automation will be relied on, with high-tech robotic machines taking the lead.
- The need for qualified staff to adjust, maintain and service these machines will be enhanced.
- Interaction between the education system and the business will need to be strengthened.
- Collaboration between individual research centers and universities on the one hand and entrepreneurs on the other will become an integral part of the company's staffing.
- The basic requirement for the employees in the enterprise will be digital competence.
- Company management and business management models will need to reformat and adapt to new technological realities. Assuming that people still need to run the business, then a completely new entrepreneurial culture must be trained, coherent and understanding the needs of the factories of the future.
- Interaction between the different units in the industrial enterprise will undergo a radical change because of the increasingly diminishing role of the man in favor of the machines.
- One of the important advantages of Industry 4.0 is the dramatic increase in productivity and hence the economic profitability of the enterprise. Experts predict that initially machines will "take off" the work associated with monotonous and repetitive movements that are so characteristic of the production line. This does not mean that work done by man will surely be unnecessary. People are still better at creating unique and innovative products.

3. Analysis of the readiness for digital transformation in Bulgaria

Method of performing the analysis:

Step One: Initially, a qualitative analysis was carried out using indicators and data for the past 5 years for each economic activity. These advocates include: state support for offices and technology transfer centers, funded projects from the National Innovation Fund, support for projects under OP QI 2007-2013, number of companies owning patents, number of companies owning trade marks.

Step Two: A quantitative analysis has been carried out using a number of indicators and data for them over the past 5 years for each economic activity organized in groups:
- Internal factor - (number of enterprises employed, production volume / services provided, turnover, added value - as part of industry and services and as part of output / services, labor productivity, investment in FTA)
- External factor - (export, import, trade balance, realized competitive advantages - production and export specialization).

The sum of the assessment of the internal and external factors gives the total estimate of the quantitative factor.

Step Three: Cross-section identifies industries with great potential for digital transformation, the logic being to find a cross point between strong areas of science and technology development and entrepreneurial activity.

As a result of the calculations, Bulgaria finds itself in the group of "modest" innovators and aims to find a place in the group of "moderate innovators" in 2020-2023 (Figure 1). For this purpose, the average values and the growth rate of "moderate innovators" for the period 2013-2018 were calculated for all innovation spheres. Also, the necessary growth rates of the innovation indexes have been calculated to achieve the target in 2020.

Although innovation capacity has improved since Bulgaria joined the EU, by 2018 the overall picture shows achievements well below potential (see Figure 2). Bulgarian companies spend 0.39% of GDP on R & D, compared to 1.31% in the EU, the percentage is about 3 times lower. Similar is the ratio to public spending. Bulgarian companies occupy 105 and 106 places in the world in innovation and business complexity.

![Fig. 1 Comparative analysis of European Innovations](image1)

![Fig. 2 Innovation activity of Bulgarian enterprises](image2)
The implementation of digital technologies for industrial enterprises in Bulgaria is below the EU average and progress in this area is limited. Although more and more small and medium-sized enterprises (SMEs) are selling online, their number remains small - 6% in the country and 3% in other EU Member States. It is important to note that 74% of the ICT sector companies are export-oriented and poorly represented on the national market. There is insufficient capacity in many industrial sectors, which prevents enterprises, especially SMEs, from benefiting from the deployment of ICT-based innovations. Because of the higher wages in the ICT sector, the more interesting job and career development potential, capable ICT professionals work in specialized foreign software companies. In this respect, the development of the ICT sector is causing difficulties for smaller companies, including those in mechatronics and the whole manufacturing industry. Recently, the development of technologies, especially cloud technologies, has enabled many small and medium-sized enterprises to meet the challenges of ICT infrastructure management, platforms and services without ICT professionals.

As a result of the Quantitative Analysis, it is established that in the context of Industry 4.0 the development of the industry is related to the implementation of structural industrial reforms in three main directions:

- **Innovations** - both technological and non-technological (new marketing tools and new organizational market practices).
- **Structural interconnections** - it is important to achieve 3 effects: economies of agglomeration of production; economics of specialization; technology transfer.
- **Added value of work** - the emergence of new forms of value creation and employment, for example through the provision of services along the chain. Rich Data Collected by Smart Devices (Big Data) can be used with intelligent algorithms to offer innovative services.

The mobile service profile shows that Bulgaria is lagging behind the EU by the coverage of 4G Mobile Internet, "Broadband Mobile Broadband", "Radio Frequency Spectrum for Wireless Broadband Communications" and "Employees Mobile Devices". While Bulgaria is about the average for the European Union, according to the indicators "coverage of 3G mobile Internet", "mobile access" and "market share of the leading mobile operator". (see Figure 3).

Bulgaria's e-business profile shows that industrial enterprises are at the EU average by the indicators "enterprises with a complex functional website", "social media companies" and "Internet advertising enterprises". (see Figure 4).

Researchers of Digital Management and Marketing at the University of Salford, UK, have developed the "Digital Maturity Business Model," presented in Figure 5, to explore levels and appropriate measures to move organizations from one level of digital transformation to a higher one.

---

**Fig. 3. Bulgaria's mobile service performance profile**

![Graph showing mobile service performance profile](image)

**Fig. 4. E-business profile of industrial enterprises in Bulgaria**

![Graph showing e-business profile](image)
The survey of 367 Bulgarian enterprises in the period April 2017-February 2018 from all regions of Bulgaria and from almost all traditional sectors shows that about 5% of small and medium-sized companies in the country are still in stage 0. The main problem for them is to develop their online presence. For companies at the top level - 68% of digital maturity, a transformation is needed from providing online information to digital business. For commercial companies, this means the development of e-commerce, and for other companies - active engagement with current and future clients of the companies. Most of these companies have digitalized the processes of accounting, part of production, have some elements of customer relationship management, but still lack a solid online presence and interaction with customers (Figure 6). 20% of the industrial companies fall into the second digitalization level, 6% - they belong to the third level of digitization and only 1% are ranked in the fourth level of digitization.

The main breakthrough that can be done is that only a small number of enterprises have fully digitized their internal processes, as well as value chain and customer relationship relationships. They encounter serious problems related to the volumes and quality of raw materials; issues related to information technology, their exchange and sales and sales; problems with the increasing food dependence of people and the pursuit of comfort in every field and at every level, issues related to the use and management of technologies.

As a result of the cross-analysis, potential sectors of the economy were identified with readiness for digital transformation – Physics, Biology and Chemistry. The identified industrial sectors and technological areas with potential for digital transformation are: artificial intelligence robotics, biotechnology, food technology, nanotechnology, thermodynamics, green technologies, medicine, nuclear chemistry, energy technologies, etc.

4. Model for Digital Transformation and Digital Enhancement

Human spirit, ingenuity and entrepreneurship will also play a major role in the industries of the future. Entrepreneurs face the challenge of building and developing digital businesses that are sustainable and effective in the future. The digital business model creates opportunities for generating value in a new way, using the benefits of the digital environment. The digital business model is based on the traditional principles of strategic marketing
management: products for specific markets through specific technologies but expressed in new concepts: Digital content is the product or service, the experience is the market that consists of customers who have the opportunity to create the product or service with the organization, share information and bring about increasing demands and platforms - the technologies, software and hardware that make the product delivers. According to some researchers (4), these three components are used by successful digital companies to distinguish themselves from competitors in the market. Smaller industries can begin to create a new business model by changing one of these three components.

The business model for building a digital business consists of the following elements:

- Digitization of document turnover of the company - working instructions; production and organizational forms; requests for purchases and deliveries; product specifications;
- Real-time production monitoring - working with wireless sensors and equipment that monitors electronically the performance of production operations (IoT: Internet of Things);
- Introducing the so-called smart machines and equipment-based processes that can track and analyze incoming information and take stand-alone decisions;
- Connecting the production with the Internet through various B2B and B2C Internet networks - (Blockchain).

5. Recommendations for successful digital transformation

In order for the industrial enterprise to be digitized, managers must be aware of the transformation. They need to be able to develop a scenario, model processes, and be able to use process management tools. It is necessary to understand the correspondence of the chosen transformation with the corporate strategy. If the tally match is missing, the success of digitization is doomed. It is necessary to make sure that corporate investments aim to bring innovations to the organization. Recognize the pressing need for the organization to undergo technological transformation. They realize that it will require a transformation in corporate culture as well as in internal and external communication of the enterprise. It is necessary to introduce teamwork, each team being empowered and responsible for a specific internal process, analyzing, documenting and auditing the process in order to build an efficient process architecture of the industrial enterprise. Undertakes activities to create digital infrastructure - artificial intelligence and cognitive systems, machine self-learning, mobile applications, mobile technologies (digital lock) and digital platforms.

On the basis of the analyzes and the recommendations made, a model for digital transformation is proposed to the industrial enterprises. Figure 7 shows the model for access to the Blockchain system of the industrial plant.

Conclusion

Undoubtedly, the digital transformation will have a positive impact on the efficiency and the formation of competitive advantages for the Bulgarian industrial enterprises. The benefits of digitization are numerous: the creation of an appropriate digital platform will allow the categorization of Bulgarian enterprises by industrial sectors, size, produced goods and services, capacity, realization markets, industrial certification. The establishment of appropriate digital infrastructure will enable the creation of profiles of Bulgarian enterprises as well as existing and potential business partners, keeping up-to-date information about the conditions for participation in the single European market, access to foreign markets and requirements of the European legislation. It will allow for adequate feedback from investors on concluded and executed transactions, references to the quality of executed contracts, real integrated and developed innovations and research. Bulgarian sales representatives will have permanent access to the platform at any time, from any location and from different mobile devices. Everyone will have the technology of automatic notification for potential interest in a company, both from Bulgaria and abroad. This will optimize the work of sales representatives by defining specific goals directly linked to increased exports. Industrial businesses will be able to explore business start-up opportunities in a region, industry, and country by automating the management of links with outside companies and automated notification of a particular sales representative.

Analytical results show that Digital Transformation facilitates business processes, decision making, and interaction with value chain partners and end-users. It is a prerequisite for gaining strategic advantages over competitors, opening up new markets not only from digital companies but also from traditional businesses. Bulgarian businesses do not yet have the necessary digital maturity, but their potential is to increase their basic indicators of technological readiness and innovation up to the average for the European Union by 2023.
References


[5] Data from SAPI, BSAW, data from the Agrostatistics Department at MAF, data from FoodDrinkEurope, www.nsi.bg


[7] EC, Agriculture and Rural Development (AGRI), Prospects for agricultural markets and income in the EU


