

ICT in the process of formation and development of convergence technologies

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ABSTRACT

The current stage in the development of global society is characterized by a new wave in technological advancement, labeled as “The Fourth Industrial Revolution”. That leads to the arise of many problems for many countries in a condition of multisided globalization - developed, developing, and especially those in transition, concerned with industry’s further development. This field, known as reindustrialization, imposes the need for the stimulation of processes corresponding to a new infrastructure of real economy. From a stage of technical advancement, the economy transforms to a stage of technological advancement with the use of nanotechnologies, biotechnologies, information technologies ect. This article analyzes problems, connected with the new fields in the production sphere of economy and the development of contemporary fields in the industry. These new technological fields are being reviewed in the aspect of their coordination and convergence, especially concerning ICT, which are attributed to production, as well as having a predominant importance to the sphere of services. Research is conducted concerning the role of ICT in their manifestation as technologies with a common application and also in their quality as basic technologies for the development of industry.

Keywords: information and communication technologies (ICT), reindustrialization, convergence.

INTRODUCTION

The current stage in the development of global society is characterized by a new wave in technological advancement, labeled as “the Fourth Industrial Revolution”. That leads to the arise of many problems for many countries in a condition of multisided globalization - developed, developing, and especially those in transition, concerned with industry’s further development. This field, known as reindustrialization, imposes the need

for the stimulation of processes corresponding to a new infrastructure of real economy.

The Fourth Industrial Revolution provides an upgrade from the basis of digital revolution, in the way of combining a multitude of technologies that lead to unprecedented changes in the paradigms of economy and business, society and individual, as well as transformations within entire systems such as countries, economic branches, companies and society as a whole [1].

Through the last few decades technology

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has been a source of serious economic transformations. In this period, we are witnessing a manifestation of an information-communication technology (ICT) revolution, which allows for a wide reorganisation of production in different industrial sectors with the aid of new technology, which in turn, causes expansion in the production of high technology goods and services. Meanwhile, the economic growth in developed technologies is accompanied by the growing role of the service sector, the repeated development of technologies, related to changes in the models of consumption and deindustrialisation [2].

The development of ICT as complex technologies is the result of divergence and convergence within individual sectors and technological branches. Divergence and convergence are both phenomena and concepts that mark a certain type (or variation), specifics in quality, activity and development of objects from different kinds, within a certain timeframe. They are inherent to all objects such as systems, structures, relationships and connections, networks and complexes from many varieties, and determine the ability of same objects to be divided in parts and be assembled in a new whole. Divergence and convergence are a manifestation of the universal activity of nature, society and thinking. They are realised in the form of two distinct and mutually connected processes.

The term „divergence“ comes from the latin „divergere“ (separation, distancing), and „convergence“ – from the latin „convergere“ (approaching, merging). In linguistic aspect „divergence“ and „convergence“ have their synonyms: in synergetics, synonym of divergence is „bifurcation“ – a term meaning splitting, separation, ramification, and a synonym of convergence is the term „conversion“ – defining processes of alteration or transformation. However, „conversion“ as a term does not fully align with „convergence“ due to the fact that it typically means a transformation from one type to another, or from one quality to another. Convergence is when two or more differ-

ent things combine. Technological convergence is seen when different forms of technologies coexist within a single device, share resources, and interact with each other thus creating new technologies and improvements [3].

In the treatise [4] of „technological convergence“, it is defined through the view of its technical as well as functional side. In that case, it is determined as a process, in which telecommunications, information technologies and media – sectors that were mostly developing independently from one another, expand together. The technical side is connected with the ability of whichever infrastructure to transport whatever type of data, while the functional side means that consumers can integrate many different functions in a single, unique device that can execute many tasks.

In the process of bringing together different technologies, both concepts of integration of convergence are important. There is, however, a difference between an integrated and convergent technology. Integrated solutions use an interface for application programs or other types of interfaces for system connections. In an integrated system, there is a distribution between a multitude of systems, all coordinated through a device acting as a mediator. That is different from the common solution, because this type of technology depends on different systems, that are interconnected with the aid of connectors. Technologies can be brought closer together on a physical, as well as on an applicational level. Convergent solutions are believed to be more stable than the integrated ones, due to the fact that on the outside, they are perceived as a single, functionally connected system. In this case, convergence can be defined as the highest level of integration [5].

During the analysis of introduction models of ICT and their role for enterprise innovation the following division is employed based on their type of application – common and specific. Despite the conditionality and inconstancy of this division their common application leads to

the event of technologies, which are commonly used in all sectors (including the final consumers) and in connection to performing different functions (mobile phones, e-mail, computers, networks, office packages, the Internet, websites, etc.), and specifically – paired with applications within specific sectors and for specific functions (production, marketing, organisation). Convergence is usually preceded by a process of diffusion. The solutions for implementing diffusion models highly depend on the type and purpose of technologies. Implementation of common technologies usually has a much lower innovational influence and economic effect on enterprises, compared to the implementation of specific ones, but is often a prerequisite which creates readiness for a quicker and less problematic introduction, because consumers are partially skilled in that aspect. Common technologies mainly have a preventive innovational nature – they are environmental factors, in whose absence great problems with enterprises could arise. Typically, specific technologies are implemented due to a conscious need and have a direct measurable influence over the efficiency of the organisation.

PROCESSES OF CONVERGENCE OF TECHNOLOGIES ON A GLOBAL SCALE

Nanotechnologies, biotechnologies, information technologies and cognitive science are different fields which are brought closer together as „Convergent (leading) technologies for improving human performance“ [6]. The merging of these technologies is pointed at an improved social productivity, more effective emergency reaction, and evolutionary progress. This new branch describes the crossing of activities carried out by scientists in the fields of: cognitive sciences - developing approaches for realizing direct communication between the brain and the evolution of our brain abilities; nanotechnologies - who construct it; biotechnologies - which apply it; information technologies - which observe and

control it.

The three main aspects of the manifestation of ICT convergence are: convergence of services; of networks; of devices. On a service level convergence ensures the rise of functional capabilities of users through a unified infrastructure for different services and solutions based on computer technologies and broadening of the capabilities of each service. Convergence of networks means convergence of technologies and systems, ensuring the ability for service convergence. Convergence on device level gives an opportunity for the operator and provider to work with different manufacturers with different technologies and to offer new effective services.

Convergence and the network approach in industry encompass all elements of society and are of fundamental importance for the development of information technologies. This is expressed through:

- the unification networks with physical reality through Internet of Things (all-around implementation of equipment with sensors and calculating devices connected to the network for all aspects of human life) and through funds – creating and navigating Virtual Reality (VR and AR).
- the formation of highly saturated information systems depicting both virtual and physical reality (graph knowledge bases - Google Knowledge Graph, Bing Knowledge Graph, etc.);
- the creation of systems for the processing of oversized database volumes in real time mode (Big Data, complex event streaming);
- the usage of networks for highly intelligent system analysis of information (analysis of natural language, handwritten input, speech, images, video, etc.);
- the usage of networks for increasing the accuracy of autonomous transmission devices;
- the usage of the achievements in the aforementioned fields for revolutionary breakthrough in the development of robot technology and increasing the production automatisation.

Also, these changes in ICT affect fields like nano and biotechnologies, the creation of new materials, alternative energetics and means for long term energy conserving, 3-D printing.

TECHNOLOGICAL AND INSTITUTIONAL CONVERGENCE IN ICT

Institutional convergence is connected with processes of merging, assimilation of economic subjects, through which to the subject's technology a different one is added, which can be complementary. This is the opposite process of outsourcing, in which activities and functions are exported from one economic subject to another one.

Institutional convergence is an expression of the strive of institutions to assist in the technological development and innovations, including ICT, in different levels of economy. In connection to that, in 2016 the European Commission published its „Program in the Field of Digital Technologies“ [7] which aim is to achieve a unified digital market, based on operational compatibility, security, quick access for all, digital literacy, research and developmental activity in the field of ICT and the benefits from them.

On a national level certain events are realized for the fulfillment of convergence of the country with economic indicators within the EU. Such base document is the „Convergence Program of the Republic of Bulgaria“¹ in which the main policies for sustaining a macroeconomic and fiscal stability of the country are outlined, for the aim of creating conditions for economic growth. The key priorities of the program are in the field of public financing management for creating financial stability and the elimination of macroeconomic disbalances through consecutive steps for budget consolidation, and measures supporting growth.

An important aspect of strategic policies is

the increasing of productivity and marketability of economy for achieving a balanced growth, sustainable convergence and the long-term increase of wealth. Considerable contribution in this field, could be made through convergence of ICT within the frames of the national innovational strategy. Under the „Innovational Strategy for Intelligent Specialisation“ within the „National Program for Development of Bulgaria“² are identified the thematic areas, which will be prioritised until 2020: mechatronics and clean technologies; informatics and ICT; the industry for healthy lifestyle and biotechnologies; new technologies in creative and recreational industries.

MAIN TENDENCIES FOR THE DEVELOPMENT OF TECHNOLOGICAL CONVERGENCE IN ICT

From the point of sectors and intersector agglomerations of ICT, we can define a few main tendencies in the processes of technological convergence. The first one is Internal Sectoral Convergence (ISC). Here, an internal interaction between technologies is realized. For example, technological advancements in miniaturisation lead to a distribution of calculations inside devices (increasing the number of processors in a device leads to mass-parallel calculation systems), within the frames of the entire network (separation of individual cloud micro-services aimed at solving specific problems) through the increase in numbers and types of devices, through which information is interacted with, as nodes in the network (laptops, computers, telephones, mobile devices etc.). Another tendency is the External Sectoral Convergence (ESC). In this case, technologies within the same economic sector converge in the direction of technologies of a different economic sector, for example, ICT

¹*The Convergence Program of the Republic of Bulgaria (2016-2019), Ministry of Finance, April, 2016*

²*Three-year Action Plan for the Implementation of the National Development Program: Bulgaria 2020 in the period 2018-2020 Priority 5 “Supporting Innovative and Investment Activities for Enhancing the Competitiveness of the Economy”*

of the economic sector of services with operational or management technologies of industry. Between Sectoral Convergence (BSC), will be present when there is combining of technologies and products, respectively, of a number of economic sectors. Mixed cross-Sectoral Convergence (MSC) represents the complex direct and reversible relations of reciprocal intertwining of technologies. For example, the interaction of ICT in the development of nanotechnologies, which in turn create opportunities for the development of new and sophisticated means for communication networks.

Indirectly, an evaluation of the convergence and the development of ICT can be made on a national and European level based on the Digital Economy and Society Index - DESI [8], which is a complex composite marker, developed by the European Commission for the assessment of progress of different European countries in the fields of digital economy and and digital society. This index combines a number of indicators, structured in five dimensions: connectivity, human capital, Internet usage, implementation of digital technologies and digital public services. It is necessary to note, however, that the indicators „connectivity“ and „implementation of digital technologies“ do not overlap with ICT convergence.

The indicator „Connectivity“ includes the subindicators: fixed broadband connectivity,

mobile broadband connectivity, broadband connectivity speed and prices.

According to this indicator Bulgaria's performance is below the average for the EU and the advancement within the country is very limited (Fig. 1). Despite the fact that broadband services access is a necessary condition for marketability, the development of broadband networks in Bulgaria is still falling behind. The total coverage of fixed networks with broadband access is 95 % of households (97 % in the EU), but in rural regions it is significantly lower than the EU average (60 % of households versus 91 % in the EU). The new generation of accessible network coverage is 72 % of households, similar to the EU average, but is only 3 % in rural regions. Concerning ICT implementation, Bulgaria continues to be among the countries with the lowest percentage of households, subscribed for fixed broadband services (55 % of households, compared to 72 % average in the EU).

The second indicator „Human Capital“ is comprised of the following subindicators - Internet usage, and basic as well as specific digital skills.

What Bulgaria has accomplished in relation to “human capital” is considerably below the EU average (Fig. 2), but its advancement is on the average mean for the EU. Despite the presence of many highly qualified bulgarian experts in the field of information and communication tech-

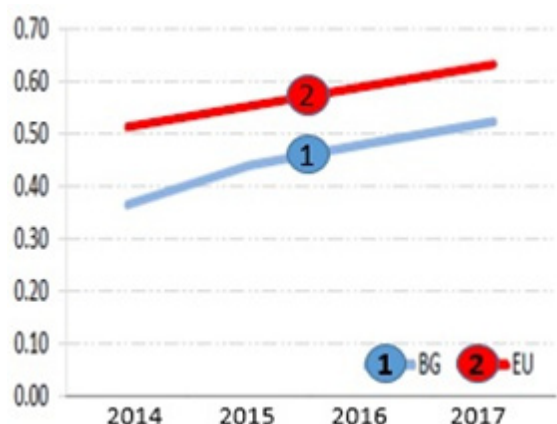


Fig. 1. Dynamics of the “Connectivity” indicator for 2014-2017.

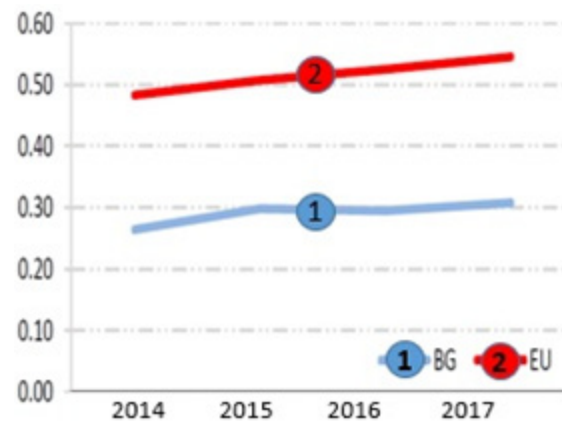


Fig. 2. Dynamics of the “Human capital” indicator for 2014-2017.

nologies, in Bulgaria there is still a shortage of programmers. The number of people possessing higher education in the field of science, technologies and mathematics has increased a little (1,4 % of total people with higher education).

In spite of that, the skills of the workforce and the population as a whole for using digital technologies are among the lowest for the EU, as only about a third (31 %) of Bulgarians possess such skills at least on a basic level, compared to more than a half of the population in total for the EU.

“Use of Internet Service” is the third main indicator that includes the subindicators - citizen usage of content, communication links and online transactions. In Bulgaria the usage of services, provided by the Internet is below the average level for the EU (only 55 % of the population use the Internet) and advancement is slow (Fig. 3).

The most popular online activities in Bulgaria are video communication and the participation in social networks, as young people (between the ages of 16 - 24) are the most active age group. Bulgarian Internet users participate the least in online banking (9,4 %) and online shopping (31 %) due to a lack of skills for digital technologies usage and lack of trust in the online environment.

The fourth indicator of digital economy in DESI is „Implementation of digital technologies“, comprised of the subindexes - „digitalisa-

tion of economic activity“ and „e-commerce“.

As far as implementation of digital technologies in enterprises is concerned, Bulgaria's performance is below the average for the EU and the advancement in the field is limited (Fig. 4). An increasing number of small and medium-sized enterprises sell their products online, but their numbers are still low – 6 % (no rise since last year) sell online and 3 % (with a rise of 2 % compared to last year) sell online to other countries - members of the EU.

The fifth main indicator includes digital public services and electronic management. Concerning digital public services, what Bulgaria has achieved, is considerably below the EU average while having a medium advancement rate. Bulgaria has had some progress in terms of offered services, but more improvements can be made for the repeated use of already available information in administrations, with the aim of facilitating various citizen activities. In addition, the use of electronic management services is still on one of the lowest levels in the EU (Fig. 5).

For the last two years Bulgaria marks a decline on all indicators, within the EU with one, two and three places respectively (Table 1). Most considerable is the lagging in Internet usage and implementation of digital technologies regardless of the value of the index remaining the same.

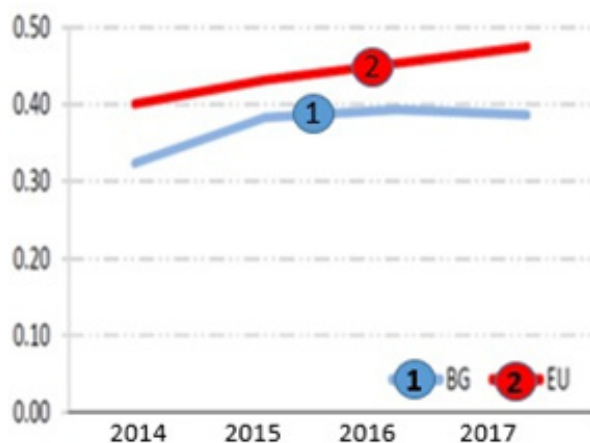


Fig. 3. Dynamics of the “Use of Internet Service” indicator for 2014-2017.

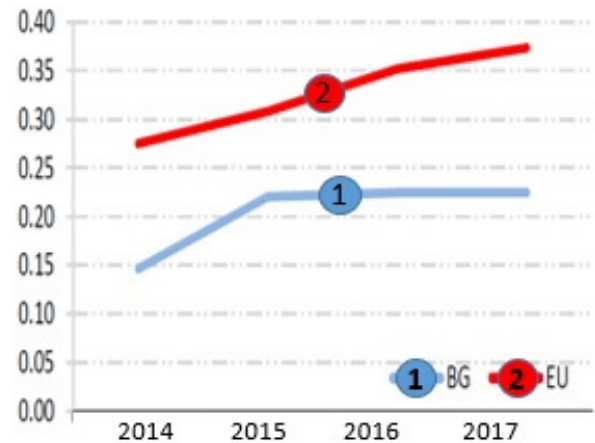


Fig. 4. Dynamics of the “Integration of Digital Technology” indicator for 2014-2017.

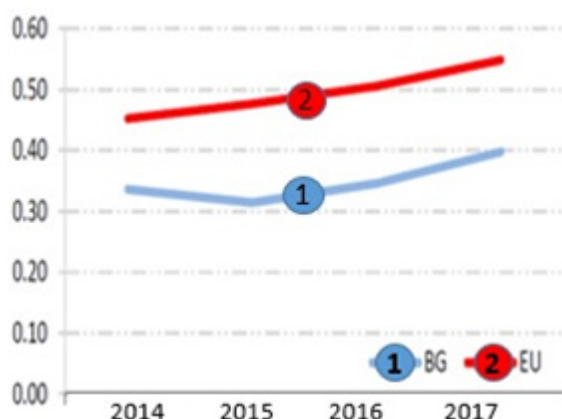


Fig. 5. Dynamics of the “Integration of Digital Public Services” indicator for 2014-2017.

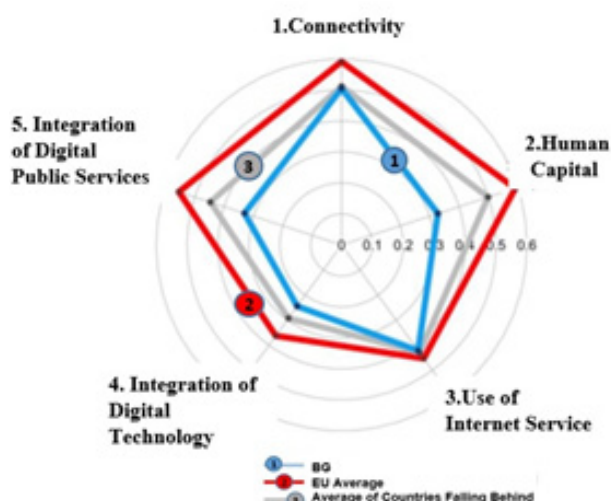


Fig. 6. Graph on the “Implementation of Digital Technologies” in the Economy of Bulgaria and the other countries in the EU in 2016.



Fig. 7. Location of Bulgaria by DESI compared to other EU countries in 2017.

Comparing all indicators for 2016 shows that ICT in Bulgaria mark a decline on all positions, both in terms of EU average and average values for indicators of falling behind EU countries (Figs. 6, 7).

Regardless of the high hopes of the administration, Bulgaria does not manage, at this stage, to develop national technological leaders, like for example Korea, Finland and the USA, but has been developing niche technologies (mainly in the field of software) and production (hard-

Table 1. Key indicators for the Digital Economy’s realization for 2016/2017.

Indicator	Place of the country		Value		Cluster Value* 2017	Value for EU-28 for 2017
	2016	2017	2016	2017		
1. Connectivity	23	26	0.48	0.52	0.53	0.63
2. Human capital	27	27	0.29	0.31	0.40	0.55
3. Use of Internet Service	23	26	0.39	0.39	0.37	0.39
4. Integration of Digital Technology	23	26	0.22	0.22	0.27	0.37
5. Integration of Digital Public Services	23	25	0.35	0.40	0.43	0.55

* EU countries falling behind

ware components). The development of digital electronics and software create a technological potential for a new approach to information services delivery and consumption.

Convergence will lead to a full and swift transformation of currently existing services in the fields of telecommunications, the media, and information technologies in such a way that these separate in present-day groups of services will merge, which will significantly blur the boundaries between them [9]. Each of these changes on its own has a vital role in the scientific - technological development of humankind but in their entirety (convergence) they catalyze the conclusive transformation of contemporary civilization. Convergence lowers the barriers for new operators and service providers entering the market. Participation of new marketers amplifies competition giving consumers a wide variety of providers and services to choose from and lower communication costs, respectively. In addition, in a technically convergent environment, the borderlines within industry will blur as well, which will allow service providers to offer said services on a multitude of markets. Undoubtedly, with the aid of technology, the production process becomes more efficient and in this way country competitiveness is raised and their vulnerability towards market fluctuations is lowered.

In the last 50 years only a few countries have successfully managed to realize a quick industrialisation and achieve stable economic growth. In all cases, the key factor of industrialisation is technology and these countries manage to successfully create a technologically developed industry. Despite evidence that technological progress plays a vital role in a country's prosperity, discussion continues over factors which prevent countries from applying technologies and innovation more actively. While technologies are connected with sustainable development, it is unclear whether they could ensure social inclusion and environmental sustainability as well. The main conclusion is that technology could be used for

accomplishing the aims in all three dimensions of sustainable development.

From an economic point of view, globalisation and fragmentation of production on a national level allowed for the propagation of new technologies through the increase of the intensity of trade with industrial goods. That propagation, however, has not always been transferred in specific opportunities for growth due to the absence of technological opportunities and the ability of individual countries to nurture the development of their own innovative systems.

CONCLUSIONS

Each change within the individual technological directions of ICT on its own has a vital role in the scientific - technological development of humankind but in their entirety (convergence) they catalyze the conclusive transformation of contemporary civilization. At the end of the current period Bulgaria did not manage to develop leading national technological directions and technological leaders like, for example, Korea, Finland and the USA, but has been developing niche technologies (mainly in the field of software) and production (hardware components). The development of ICT and their convergence in the different directions shows that, in relation to inter-sector convergence, it is manifested as a special purpose technology, and its application towards other economic sectors is mainly realised in the form of common purpose technology.

In the global technological development ICT are defined as "Main Base Technology" with key significance for the development of reindustrialisation processes, both in the fields of management and operation technologies and production.

Information and communication technologies shape the modern processes of convergence in economic sectors of their agglomeration, and inside the two sub-sectors - information industry and information services. In the field of the main (leading) convergent technologies, ICT fulfill

their role as a mediator with forward and reverse connections.

The main contribution of convergence is that it transforms information and communication technologies into a unified complex.

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