ASSESSMENT OF READINESS FOR „INDUSTRY 4.0“

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Abstract: *The Industry 4.0 initiative poses great challenges to the world, countries and companies connected with the provided digital transformation and the new intelligent technologies in all areas of the industry. This requires the development and follow-up of a national strategy for the adoption and implementation of Industry 4.0. It is important in this case to assess the Industry 4.0 readiness of each country for transformation and change. The main aim of the paper is to present, analyse and compare some of the most promised existing approaches for calculation of Industry 4.0 readiness at national level. Some results are presented and compared.*

Keywords*:* INDUSTRY-4.0, READINESS, MANUFACTURING, ASSESSMENT

1. Introduction

The European Commission's strategy for European Reindustrialization aims of increasing the industrial sector's share of gross value added in the European Union to 20% in 2020, based on European strengths in the fields of engineering, automotive, aeronautics, etc. [1]. The Industry 4.0 platform is an initiative of the German Federal Government to support German industry in the transition to digital production with intelligent, digital networks and systems that enable largely self-control and self-management of manufacturing processes [2, 3]. Especially strong is the focus of Industry 4.0 on the functions of future intelligent adaptive and predictive technical systems that need to be self-optimizing, self-configurable and self-diagnosable, enabling cognitive information processing and intelligent networking in continuous interaction with environment. That is why the strategic initiative Industry 4.0 implies integration of Cyber-Physical Systems (CPS), the Internet of Things (IoT) and cloud computing leading to what is called "smart factory".

The speed and scope of technological changes coupled with the emergence of new technologies and trends makes the task of developing and implementing new industrial strategies too complex. The Industry 4.0 initiative is a great challenge for both national economies and individual companies. To deal with it, countries should develop national strategies tailored to the specifics and capacities of their economy, based on an in-depth analysis of the factors, indicators and conditions that have the most impact on business and production systems. With regard to the national strategy, there must be a consensus of industry, academia and civil society.

An important role in building a life strategy for Industry 4.0 are the results of an assessment of the readiness of national economies to adopt and adapt the initiative. Readiness according [4] is defined as “the ability to capitalize on future production opportunities, mitigate risks and challenges, and be resilient and agile in responding to unknown future shocks.” There are different approaches to such an assessment that use different quantitative and qualitative key indicators, both for the assessment the readiness of countries and individual companies. Among the approaches to assessing the readiness of countries and national economies, some of the most significant assessments are derived from the approach developed by the World Economic Forum [4], the approach of the Danish Institute Industry 4.0 [5] and the Roland Berger readiness index [6]. In the area of company stand-alone assessment of readiness, the IMPULS model [7] is the most popular, assessing the maturity of manufacturing enterprises in 6 dimensions: strategy and organization, smart factory, smart operations, smart products, data-driven services and employees. The analysis, proposed in this paper is limited to the approaches for readiness assessment of countries. Reasoning and conclusions about global, local and group trends and initiatives are also possible. The results from assessment may be used to identify specific opportunities and challenges for individual countries for the future of production.

The main aim of the paper is to analyse the existing approaches and methods for assessing the readiness of the countries and their economies to adopt and implement the Industry 4.0 initiative. Some comparisons and analysis of the obtained results regarding the position and readiness of Bulgaria are also discussed. After the introduction, in the second part of the paper the challenges of Industry 4.0 and the main difficulties with its perception are briefly discussed. Sequentially, in parts 3, 4 and 5, three of the most representative and complete readiness assessment approaches have been shortly presented and analysed. In the last part, as conclusions, some comparisons and recommendations on the implementation of the results in preparing of national strategies for Industry 4.0 are presented.

2. Challenges and difficulties in implementing Industry 4.0 initiatives

"Industry 4.0" or IIoT are related to the new industrial revolution and focus on the integrated use of state-of-the-art information (IT) and operational technologies (OT) such as IoT, cyber-physical systems, big data and advanced data analytics and decision making methods, artificial intelligence and robotics, cloud and fog calculations, virtual and augmented reality and others, as shown in Fig.1. With a view to a more rapid adoption of the new concept by industry, it is desirable to ensure a smooth transition to these new technologies through the use of transition technologies and standards and reasonable investment to achieve the objectives, including OT and IT integration (Fig.2). There are a number of industry prerequisites: embedded devices and controllers, wireless sensor networks, RFID technologies, and more. While the hardware industry is relatively well prepared for a transition to IIoT, there are serious challenges to software applications and architectures.

Fig.1: *Basic technologies for Industry 4.0*

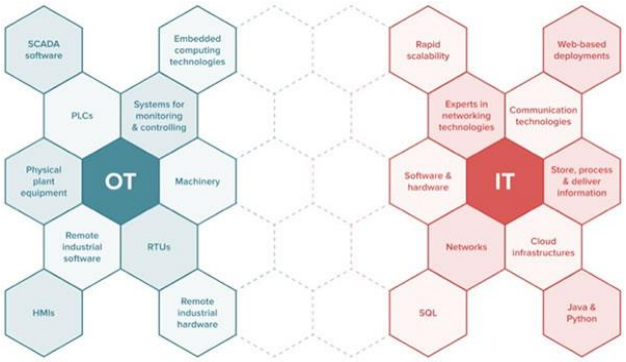

Fig.2: *Integration of OT and IT*

3. The approach of World Economic Forum

The readiness assessment of the World Economic Forum [4] includes two main components: the Structure of Production and Drivers of Production, or the key enablers that capitalize on the Fourth Industrial Revolution to transform production systems. The Structure of Production as shown in Fig.3 is assessed in terms of its complexity and scale, while the component "Drivers of Production", shown on Fig.4 includes categories such as: technology and innovation, human resources (capital), global trade and investment, institutional framework, sustainable resources and the demand environment. The study, conducted in 2018, includes 100 countries and their economies, which are valued on 59 key indicators, which are measured by internationally recognized organizations. The assessment also includes indicators from the World Economic Forum's Executive Opinion Survey (EOS) measuring different qualitative aspects of some indicators, or are used as a substitute in the case when statistical data was not available. All indicators as well as the total scores are in the intervall from 0 to 10, with a maximum value (10), representing the best situation. Indicators values are normalized in the range from 0 to 10 based on the min-max approach. The normalized scores are combined to produce the aggregated and total scores.

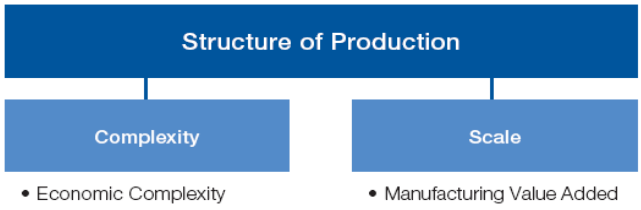

Fig.3: *Component "Structure of Production"*

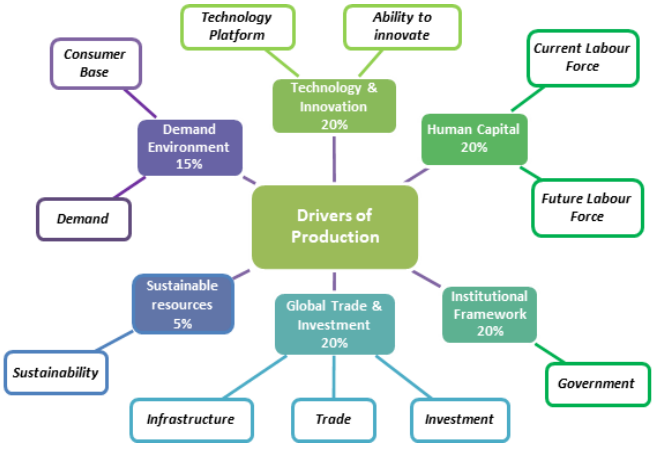

Fig.4: *Component "Drivers of Production"*

The approach does not offer a global ranking, but classifies the countries into one of the four archetypes, the boundaries of which are determined by the average estimates of Drivers of Production (5.7) and Structure of Prodution (5.7) for the Top 75 countries, ordered by the Structure of Prodution rating (Fig.5). These 4 archetypes are named: High potential, Leading, Nascent and Legacy. They are determined by the complex assessment of the existing basis (limited or strong) and positioning for the future (at risk and well). The countries in the Leading archetype are with a strong production base today and a high level of readiness for the future. The countries in the Legacy archetype are with a strong production base today but they are at risk for the future due to weaker performance across the Drivers of Production component. The countries from the High-Potential archetype are with a limited production base today but have good score in respect to Drivers of Production component. This is an indication for existing capacity for increasing of production in near future. Countries in the Nascent archetype are with a limited production base today and a low level of readiness for the future.

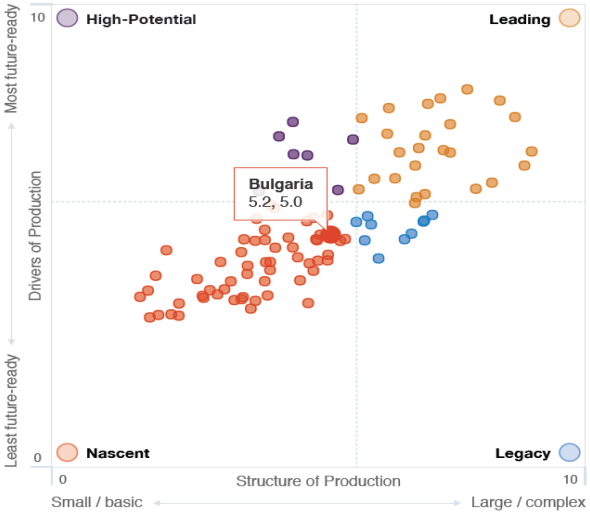

Fig.5: *Readiness assessments according the approach of WEF [4]*

On Fig.5 some of the results are shown. From 100 countries and economies included in the assessment, 25 of them are "Leading" countries, 10 "Legacy" countries and 7 "High-Potential" countries/economies. The remaining 58 countries are "Nascent" countries. The majority of the EU Member States belong to the first three archetypes. 5 EU countries fall into the archetype "Nascent". Unfortunately, one of these countries is Bulgaria, which has a score of 5.23 for Structure of Production and 5.02 for Drivers of Production and occupies 40 and 48 rang respectively. For comparison with the other approaches only, in the first six are the United States (1 st rank), Singapore (2 rank), Switzerland (3 rank), the United Kingdom (4 rank), the Netherlands (5 rank) and Germany (6 rank).

4. Danish global Industry 4.0 readiness approach

The DII 4.0 approach for calculation of Industry 4.0 Readiness Index [5] is a part of Danish Institute of Industry 4.0's annual global analysis supporting governments, companies, academics and institutions interesting in implementation of Industry 4.0.

The Industry 4.0 readiness of the countries is assessed based of 7 main pillars, which are weighted as shown in Fig.6. Each pillar comprises of different measurements, which are a total of 24. The measurements have its own weights in the overall score according to their relevance and importance. The Global Industry 4.0 Readiness report includes 120 countries. In order to obtain more adequate assessments in this approach, a score correction based on simple exponential regression is used. It corrects with higher value the higher scores and with lower value – the lower ones, according to equation (1).

$$\text{Adjusted score} = e^{0.24 \cdot \text{original score}} - e^{0} \quad (1)$$

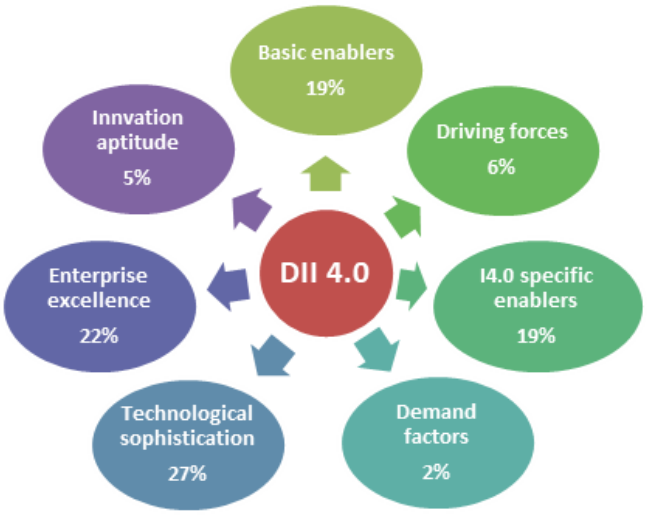

***Fig.6**: Basic pillars of DII 4.0 approach*

On the basis of the assessments received, a total of 9 groups of countries worldwide are identified, as shown in Fig.7. To all these groups certain strategies for Industry 4.0 are recommended. For groups 1 and 2 the strategy is named "Foster manufacturing & strengthen position" for 3 and 4 - "Further strengthen position", for 5 and 6 - "Catch up to protect", for group 7 is "Foster manufacturing & Complete turnaround", and for 8 and 9 - "Complete Turnaround".

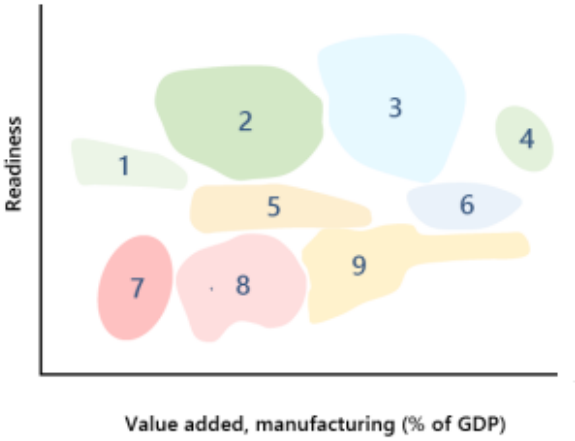

***Fig.7:** Readiness assessments according DII 4.0 approach [5]*

The results of Bulgaria put it in 9 group and occupies 63 place with a rating of 2.5 in ranking of countries by Readiness index. With the same rating are Croatia, Ukraine, Iran and Jamaica. Leading positions are for Singapore (6.6), Switzerland (6.6), Finland (6.0) and Germany (5.9). For the countries of group 9 the manufacturing is an important driver of their economies, they are not well-positioned for Industry 4.0 but quite the contrary and probably they will have problems with their status quo. Bulgaria's scores on individual pillars, compared to the average world scores are shown in the radar diagram of Fig.8.

The clustering results of the European Union countries are also presented. Similarly to the first approach presented in part 3, four groups of countries are identified: Growers, which are well-positioned for Industry 4.0, and thus their manufacturing sectors are likely to grow in the future; Leaders with high level of Industry 4.0 readiness and an important position of manufacturing; Laggards: manufacturer is moderately important but they lack of readiness and therefor the outlook is rather negative and Unprepared: manufacturing is very important however but they are not prepared for Industry 4.0, and they will probably have problems. Bulgaria falls again into the group of countries Unprepared for Industry 4.0, although it was omitted from the graphical illustration of the results.

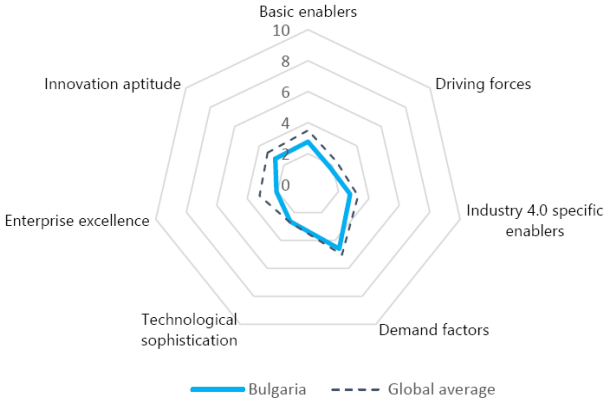

***Fig.8:** Comparison of Bulgarian scores with the global average [5]*

5. *Roland Berger readiness index*

The RB Industry 4.0 Readiness Index [6] is calculated using two categories of indicators. The first category, named "industrial excellence" includes production process sophistication, degree of automation, workforce readiness and innovation intensity. The second category covers high value added, industry openness, innovation network and Internet sophistication, and is labeled "value network". The indicators of both categories are evaluated on a five-point scale with score "5"signifying that the country is excellently prepared for Industry 4.0. Assessments of both categories are the averages of the indicator scores included. The RB Industry 4.0 readiness index is a combination of category assessments. In the graphical representation of the assessments, the index is plotted on the vertical axis, the horizontal axis is represented by the production share.

The approach is applied to the European economies as shown in Fig.9. On the basis of the assessments in both categories, a matrix is formed that roughly divides European economies into four main groups: Frontrunners, Traditionalists, Hesitators and Potentialists. Frontrunners are characterized by a solid industrial base and modern, promising business conditions and technologies (Sweden, Austria and Germany). Traditionists have a solid industrial base, but have few Industries 4.0 initiatives. This group mainly includes Eastern European countries. The third group of Hesitators includes countries with an unreliable industry base, many of them with fiscal problems. Their joining the initiative now is difficult, even impossible. Most countries in this group are from South and Southeast Europe, among which, unfortunately, Bulgaria. Potentialists are the fourth group that is characterized by a weakening industrial base but with signs of modern, innovative thinking, however, having the potential to find the right approach to Industry 4.0.

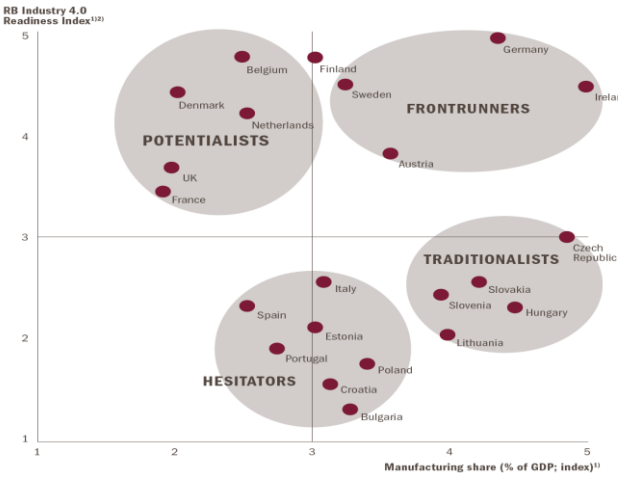

***Fig.9:** RB Industry 4.0 Readiness Index [6]*

6. Conclusions

The presented and analyzed approaches for Industry 4.0 readiness assessment have many similarities and differences. The similarities are that they use relatively simple clustering methods based on the stand-by index and production share. The differences are in the selected indicators and indicators and the selected evaluation methods, as well as the evaluation scales used. The results obtained and the analysis of the hidden, not obvious knowledge is of substantial benefit for the stakeholders, related to the development of strategies and policies for raising the index of readiness. Their in-depth comparison and analysis is forthcoming with a view to revealing the strengths and weaknesses of each of the approaches considered.

There are some shortcomings common to the approaches considered, such as:

- There are no quantitative estimates of key concepts, so indirect estimates are used.
- Strong variability and uncertainty of the information received and used

The evaluation, made using different approaches, imposes the following main global conclusions: When building national strategies for Industry 4.0, account should be taken not only of national solutions, but of global and regional conclusions. National solutions must be consistent with assessments and conclusions on readiness, as well as with the country's specific positioning. The fourth industrial revolution will cause changes in global value chains, global transformation of manufacturing systems leading to a two-speed world. There are few countries that can create a cluster of new industries. Countries can cope with transformation using different paths, each country having a way and a chance to improve its readiness for Industry 4.0. Each of the defined groups of countries with approximatelly equal readiness faces common challenges that can be shared by finding common solutions.

References

1. European Commission, Digital Agenda, http://ec.europa.eu/digital-agenda/en/digitising-european-industry.
2. Industry 4.0, http://www.plattform-i40.de/I40/Navigation/EN/Home/home.html
3. Kagermann H., Wahlster W., Helbig J., Recommendations for implementing the strategic initiative INDUSTRIE 4.0, Final report of the Industrie 4.0 Working Group, Akatech, April, 2013.
4. World Economic Forum, Readiness for the Future of Production Report 2018, Insight Report in collaboration with A.T. Kearney, available at http://wef.ch/fopreadiness18.
5. Faarup J., Faarup A., Global Industry 4.0 Readiness Report 2016, Danish Institute of Industry 4.0 (DII 4.0), 2017.
6. Berger R., Industry 4.0 The new industrial revolution: How Europe will succeed, Think Act Industry 4.0, March, 2014.
7. Lindner T., Wittenstein M., Gernandt J., Röger S., Industrie 4.0 – readiness, IMPULS-Stiftung, Aachen, Köln, Oktober 2015.